The Nutritional Improvement of Life

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By

HENRY C. SHERMAN
Mitchill Professor Emeritus of Chemistry
Columbia University

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Preface

THE CHIEF REASON for the writing of this book is that now, practically at the middle of the twentieth century, our knowledge of nutrition has reached a stage in which, as the late Sir Walter Fletcher said, it reveals much more than was foreseen. Moreover, this development has brought us both a great wealth of hitherto unforeseen facts and the establishment of unanticipated scientific principles which have extremely important liberating effects upon our thinking, enabling us to improve the life histories of ourselves, our children, and our grandchildren in ways which had been regarded as beyond the power of science until now.

If Whitehead was right in his belief that the main function of universities is to transmit from generation to generation a union of keen interest in facts with equal devotion to generalization, then, in this, the University Presses have a noteworthy part, in the publication of mature and responsible yet easily readable summaries of the sciences and their human implications.

This book completes a group of three small volumes which was begun with *The Science of Nutrition* and continued in *Foods: Their Values and Management*. Those are companion books, descriptive of the modern view of the substances needed in our nutrition and how these are furnished by our food supplies. This book is a sort of capstone to both of those, dealing essentially with the human implications of the new knowledge and seeking to make this clear and effective by approaches through the significance (rather than the techniques) of the half-century of orderly research which has brought more far-reaching potentialities for the improvement of human life history than science itself had anticipated.

We now have good scientific evidence that such nutritional improvement of life can begin before birth or at practically any time after, that in early life it can mean improvement of mental as well as physical growth and development, and that this earlier maturity can be followed by a longer period and a higher plane of full adult

capacity, with superior attainment and performance over a longer career, and a lower percentage of years of dependence.

Much of what we had thought to be attributable to heredity or fate we now find to be amenable to nutritional improvement. Both heredity and nutrition are now known to be major factors in determining the length of normal lives.

While these latest and most liberating principles of nutrition extend beyond and above what science itself had expected in this direction, they are by no means merely matters of opinion. They are the outcome of long years of objective research by the methods of the exact sciences. This book aims to make clear the significance of the findings without requiring its readers to endure any long or intricate technicalities of research.

In arrangement, this book first follows in a chronological sequence the growth of nutrition throughout the half-century of its recognition as an autonomous science. These discoveries are here presented less as distinct and completed triumphs, and more as successive steps which taken connectedly and as a whole bring us to an essentially new concept of the potentialities of the science of nutrition to improve the hitherto accepted norms of human life history. The latter half of the book discusses topics of most recent development and their implications for the improvement of life in all of its aspects. Hence it will not be repetition if the reader should meet a given topic discussed in more than one chapter.

An appendix summarizes current developments in the United Nations' Food and Agriculture Organization. A second appendix gives records of actual meals to illustrate how the guidance of the nutritional principles given in this book have worked out in the daily lives of people who, like most of us, cannot control every meal eaten but may do enough in evening-up food consumption to secure the nutritional benefits to which our present knowledge points the way. There follows a carefully selected bibliography which includes abstract, as well as original, references in those cases in which this will be a convenience to many readers.

Nutrition is everyone's adventure. This book brings out the human implications. It differs from others in its field—and from scientific books generally—in that it deals less with how the advances of yesterday were made, and more with what they can mean for today and tomorrow.

The encouragement and aid of many fellow workers, including especially M. E. Bal, M. L. Caldwell, C. G. King, Grace MacLeod, Ina Padgett, C. S. Pearson, J. M. Schwank, and A. W. Thomas, are gratefully acknowledged.

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CHAPTER I

Introductory: Nutrition as Public Concern and as Individual Adventure

DISRAELI DECLARED, and no one has disputed, that the health of its people is a prime concern of an enlightened nation. But until recently enlightenment as to the full meaning and potentialities of health, and its advancement through nutritionally guided food habits, came slowly. Governmental departments of health concerned themselves chiefly with diseases and death. Or, as F. G. Boudreau and H. D. Kruse put it, health officers were preoccupied with saving lives by bringing infections under control through quarantine and immunization.

When the United States Government in 1894 showed its first official recognition of concern for human nutrition it was by including a small item for investigations of the food and nutrition of man in the Congressional appropriation for the Department of Agriculture.

The wording of the item in the appropriation act seems rather to suggest economic interest than any clear concept of a constructive advance of human health through nutrition.

However, we know that W. O. Atwater, who was chiefly influential in bringing about this Federal recognition of the need for investigation in human nutrition, pointed out that a person may live on a higher or a lower nutritional plane. In annual reports of the Storrs (Connecticut) Agricultural Experiment Station and in his other writings, he advocated comprehensive studies of the food and nutrition of man in the belief that they could show the way both to better economy in the use of food resources and to more scientifically guided nutrition with resultant higher working efficiency and enjoyment of life. His judgment has been confirmed.

About four decades later we find the Secretary of Agriculture writing officially in his annual report, of the whole great movement for agricultural adjustment, that its goal is optimal nutrition; and Dr. James S. McLester saying in his presidential address to the American Medical Association that the newer knowledge of nutrition offers greater vigor, increased longevity and a higher level of cultural attainment. "To a measurable degree," he added, "man is now master of his own destiny, where once he was subject only to the grim hand of Fate."

As McCollum has clearly taught since the early 1920s, this is more than a matter of escaping nutritional deficiencies. It has for each individual not only a preventive and corrective, but a constructive potentiality as well, inasmuch as there is or may be an important difference between merely adequate and optimal nutrition. And J. F. Williams, doctor of medicine and teacher of hygiene, has at the same time emphasized that, both for the public and for the individual, health is not merely the absence of disease, but a positive quality of life which can be built to higher levels. Still more recently there has been a rapid growth of appreciation of the fact that both individual and public health can be advanced through the improvements of nutritional status which we can bring about by a wiser use of food.

That this constructive view of the potentialities of nutrition for the improvement of human life has progressed so rapidly during the second quarter of the twentieth century is doubtless a combined result, of the awakening of nutrition consciousness and of the experimental development of the science of nutrition by the methods of the exact sciences, thus carrying its new view through the era of opinion into that of objectively established scientific fact.

Of the various criteria by means of which the nutritional improvement of the life history has been measured objectively, perhaps the most significant is the lengthening of adult life with an even more than proportionate increase in the "length of useful life" or "period of the prime" which lies between the attainment of full adulthood

and the onset of senility. That growth and development should be expedited, adult health built to higher levels, and old age deferred, all in the same individuals, by an added amount of a single nutrient (as with vitamin A), or by simple change in the relative amounts of different natural foods in a normal dietary, was a finding which to many people seemed too good to be true. It called for a change in what had seemed to be a well established view; namely, that the length of adult life is determined simply by heredity. There had been previous studies of longevity, made by very different methods which enabled investigators to correlate longevity with heredity and with nothing else. Under those conditions it came to be assumed and was taught, far too dogmatically, that "we cannot add years to our lives though we can add life to our years" and that "there are many ways in which we can shorten our lives but the only way to lengthen them is by the selection of a longer-lived ancestry." Such teaching can now be seen to be misleading because it states only a part of the truth as if it were the whole; and it is not true to the spirit of science because it is fatalistic and tends to close the mind. The new evidence of full-life research now shows that *nutrition as well as heredity* is a major factor in determining the length of life. It is now clearly incorrect to believe that the length of our lives will be determined exclusively by our heredity. Heredity will have its influence, but food habits will have their influence as well. We cannot select our ancestors, but can select our foods. We can and should *both* add life to our years *and* add years to our lives.

And the extra years are always to be thought of, not as added to old age, but as inserted at the apex of the prime of life. Recent research has established the principle that with nutritionally superior food habits, the life "cycle" becomes longer because it has been pitched and lived on a higher health level throughout.

The year 1931 offers a landmark and milestone in the establishment of the international quarterly *Nutrition Abstracts and Reviews* and the publication of its first article, "Nutrition and Human Welfare," by the late Sir Frederick Gowland Hopkins, then professor of biochemistry in Cambridge University and president of the

Royal Society. Hopkins' eminent qualifications to speak at once for the biological and chemical sciences, and his outstanding and world-wide reputation for soundness of judgment and carefulness of expression, gave great weight to his interpretation of evidence then existing regarding the potentialities of nutrition for human health, efficiency, and welfare. He reasoned that, whatever may be true of evolutionary history, it is sure that in deciding the status and capacities of an existing generation, Nurture may assist Nature to a degree which is unmistakable, and that in this respect "right nutrition is a factor of prime importance."

Hopkins also emphasized the fact that the full importance of nutrition to health and efficiency can be demonstrated only by controlled observations and experiments conducted according to the principles of the exact sciences. "In more superficial studies," he wrote, "the influence of nutrition may escape recognition." Thus when a race or community is found in equilibrium with an environment which includes its food supply, the mere fact of survival is too often taken as evidence that the food is nutritionally satisfactory. On this supposition a lack of vigorous health or efficiency may be wrongly attributed to racial inferiority, it being too often forgotten that the equilibrium reached is one in which the community, while managing to survive, may yet be functioning at levels far below those possible to its innate capacities. In further clarification and emphasis he wrote: "That scientific research during recent years has greatly emphasized the importance of right nutrition as a factor in human welfare is very sure," and that it "has wholly changed the outlook in the domain of nutrition."

This greatly increased recognition of the potentialities of nutrition for human welfare continued to grow during the subsequent decade, as explained in 1941 by Sir John Orr who pointed out even more explicitly the relation of nutritionally superior food supply to individual and national well-being.[1] He emphasized the fact that the further knowledge which had been gained in the ten years from 1931 to 1941 had "thrown into clearer relief the contribution which

[1] J. B. Orr, *Nutrition Abstracts and Reviews,* volume 11 (1941), 3–11.

the science of nutrition can make to human welfare," and that in planning for such welfare, food should be treated not simply as a trade commodity but as the first and most important material requirement for the better life. Hence he argued strongly that the production and distribution of food should be based on the nutritional needs of the people. Hence also, there arise such questions as what constitutes a diet adequate for health and to what extent would national food supplies have to be increased "to meet nutritional needs on the standard now known to be necessary for health." Orr also pointed out that the great improvement in health and physique in the United Kingdom in the preceding 20 years was indicated by an increase of from 2 to 3 inches in the average stature of children leaving school, by the fall of the infant mortality rate in England from 97 of every 1000 live births in 1918 to 53 in 1938, and by the fall in the tuberculosis death rate from 15.7 of every 10,000 individuals living in 1918 to 7.2 in 1935. This improvement in the health of the people, Orr held, must be attributed to changes in controllable environmental factors, of which the greatest has been food.

Orr also emphasized the growing volume of evidence that food which is only relatively faulty may be largely responsible for "some forms of mental depression and abnormal psychological states" and that "one might predict" that the prevention of such conditions by better diet may be even more important for human welfare than the cure of frank deficiency diseases.

Sir Richard Gregory wrote in 1937 that "rising income, associated with increased consumption of milk, eggs, fruit, and a few other foods, goes hand in hand with decreased death rate, better growth of children, greater adult stature, and much improved general health." Work of this kind, he said, "provides a biological basis for social and political thought, and suggests how the growth of knowledge may be used for the improvement of mankind." We are, he holds, at the beginning of a new era of biological knowledge with new possibilities of physical and mental health, if our resources are planned intelligently with the object of satisfying real human needs. And the only rational foundation for such planning is scientific re-

search into the character and extent of these human needs and the resources available for meeting them.

In no other field of science, Boudreau held in 1947, has our knowledge advanced more rapidly than in nutrition, and he then emphasized how the principles, originally worked out by laboratory animal experimentation, have "received dramatic illustration in the United Kingdom during the war just ended." The results thus achieved by the Ministry of Food brought the Ministry of Health to the conclusion that "Nutrition is the very essence and basis of national health."

The British accomplishments thus cited by Orr, by Gregory, and by Boudreau have also been summarized by the Nutrition Foundation, of which the scientific director is Dr. C. G. King, as follows: "Keeping in mind that the British population was subjected (by war) to increased stress from poor housing, greater risks in sanitation, loss of normal provision for sleep and recreation, and lessened medical care, it is remarkable that from an intensive nutrition program during the war, they achieved the best health records in all British history. . . . Stillbirths declined by 28 percent, infant mortality declined by 13 percent, and neonatal deaths declined by 13 percent. These improvements have been continued through 1946 and 1947, so that since the nutrition program was made effective, all-time favorable health records were achieved in each succeeding year through the six-year period from 1942 through 1947. Nutrition scientists appear to be on sound ground in suggesting that improved food habits alone (made effective from infancy onward) probably would add another ten years or more to the life span of our citizenry, within a generation. The intervening and added years would be characterized also by increased physical and mental vigor and a higher level of health in nearly every respect. One of the greatest gains would be in the deferment and partial elimination of the degenerative diseases that now are dominant."

Thus the awakening of nutrition consciousness and the steady advances of nutritional knowledge are now influential in public health work; they are also offering the adventure of higher health

and longer life to all individuals interested in nutrition. That wiser choice of food can be a way to higher, more positive, health is now no longer held to be merely opinion. Rather it is held as objectively established fact.

Even in its first edition, Dr. Mary S. Rose wrote in the preface to her *Feeding the Family* that, while many things contribute to health—sleep, fresh air, and exercise, for instance—the foremost consideration is food. And that those who regard their own welfare and desire to give their children the best possible equipment for the stress of modern life are asking how to choose food wisely.

It continues to be increasingly true, as the *Journal of the American Medical Association* has remarked editorially, that: "Buoyant health as distinguished from merely passable health is coming to be more appreciated." This book seeks to evaluate that anticipation. And it is hoped that this introductory chapter, even though sketchy, may indicate something of what the following chapters seek to explain of the significance of nutrition in the twentieth century both as an important factor in the public health and welfare and as an opportunity for enhanced attainment and accomplishment on the part of every interested individual, whatever his or her field of work may be.

As President James B. Conant of Harvard has expounded the importance of an understanding of science by all thinking people and not only technically trained scientists, so not only those who specialize in the science of nutrition but all citizens of the world of today should understand the nature and significance of the influence of food habits upon health, efficiency, and well-being.

What is needed, and what this book seeks to aid, is not simply a further arousing of nutrition-consciousness but also the building of a sound understanding of what science has now shown to be practicable in the improvement of life processes and life histories through nutritionally guided use of food, and the significance of such improvements for the individual and for the human family.

Nutrition is everyone's adventure.

CHAPTER II

Nutrition in the Nineties: Beginnings of Permanently Organized Research in Nutrition

UNTIL LATE IN THE 1890s the word *nutrition* was not much used. For instance, in E. A. Schafer's comprehensive and excellent *Text-Book of Physiology* published in 1898, it occurred in none of the chapter titles and only once in the index. Physiologists spoke rather of *metabolism*,[1] while if a physician called a patient well-nourished one could not assume that this meant anything more than a desirable degree of fatness, a good proportion between the body's weight and its height.

The researches of Antoine Lavoisier and of Justus von Liebig among chemists, and of Max von Pettenkofer and Karl Voit among physiologists, had included highly significant contributions to what we now call the science of nutrition, but these were essentially individual projects. Institutionally organized, continuing researches began earlier in the nutrition of farm animals than of man, because of the establishment of permanently planned researches with farm animals in the agricultural experiment stations, several of which were founded during the latter half of the nineteenth century, notably in England, Germany, and the United States. In this country,[2] while the Federal government provided much of the support, such research stations were established in all of the States and each

[1] By derivation meaning simply change, the word *metabolism* came to be used as a chemico-physiological term for the exchanges of matter and energy which are involved in nutritional processes, generally not including those of digestion.

[2] This book is written from an American viewpoint, but aims to reflect world progress in the building, and in the functioning, of the twentieth-century science of nutrition.

had practically complete self-determination in its choice of research projects.

Dr. W. O. Atwater—then professor of chemistry at Wesleyan University, previously a graduate student under Professor S. W. Johnson at Yale—was chosen as the first director of the Storrs Agricultural Experiment Station in Connecticut and he extended its scope to include research in human foods (*foods* as distinguished from *feeds* or feedingstuffs). Dietaries were also studied in cooperation with the U.S. Bureau of Labor.

Atwater believed that the food supply of the United States, and the dietaries of its people generally were too high in fats and sugar and too low in protein (at least relatively) for best results. He urged that farmers take the first step in remedying this error by "the production of plants richer in protein; and meats with more lean and less fat." He held that the European dietaries and dietary standards with their higher protein and lower fat content than ours (for people in comparable economic conditions) represent the food consumed by people believed by physiologists to be well nourished.

In 1892 there appeared the 4th Annual Report of the Storrs (Conn.) Agricultural Experiment Station, a section of which, on "Food Investigations" by W. O. Atwater and C. D. Woods, contained a group of six papers. In the introductory paper of the group, Atwater wrote that the findings then in hand, "when united with the results of research elsewhere, serve to establish certain principles of the science of food and nutrition which have a direct bearing upon hygiene, and upon domestic and national economy, and which the writer believes to be worthy of more consideration than they have thus far received, especially in the United States."

Thus, early in this decade Atwater had set forth his view that the composition, digestibility, and nutritive values of foods, and the requirements of human nutrition demand earnest and thorough study which would need continuing support. His writings were doubtless influential in persuading Congress to add, in 1894, an item to the annual appropriation of the Department of Agriculture

to enable it to provide for investigations in the food and nutrition of man.

Food economics was probably more clearly visualized in Congress as calling for such investigations than was either the upbuilding of the science of nutrition, or any expectation that such work would show the way to higher health, though Atwater's writings had suggested that Americans might improve their health by eating more protein, and less of fat and sugar. In this, Atwater was accepting the then prevailing opinion of European physiologists, especially of Voit and his followers of the Munich school. And as Americans were believed to work harder and known to earn more, Atwater held it logical to revise the Voit standard upward in order to obtain a standard suitable to American conditions. "The American workingman," Atwater wrote, "is better paid, better housed, better clothed, and better fed than the European. He has better opportunities for self-development, more to stimulate his ambition, and more hope of reward if his work is efficient. He accomplishes a great deal more. That this superiority is due to more nutritious food, as well as to greater intelligence, is hardly to be questioned."

Yet, self-congratulatory for the American as was the general attitude thus expressed, Atwater evidently believed that the abundant American diet called for correction not only on grounds of economy in the use of resources but also for the improvement of bodily well-being. For Atwater at this time also wrote: "The agricultural production of the United States is out of balance. Our food supplies for man and beast contain an excess of the materials which serve the body for fuel, and are relatively deficient in the nitrogenous compounds which make blood, muscle, and bone." Here followed a strong and wise recommendation of greater cultivation and use of leguminous crops.

Atwater considered collectively the studies of dietaries made by himself and his co-workers in the northeastern United States during the period from 1886 to 1893 and tabulated them with the two chief standards of the time (Table 1). At that time he wrote: "This investigation of the habits of food consumption is a branch of the general science of nutrition." This must be one of the earliest

specific references to nutrition as an autonomous science. Recognition of nutrition as a science in itself appears to have spread largely from the writings of Atwater.

TABLE 1

AMERICAN DIETARIES SUMMARIZED BY ATWATER IN 1893
(Per Man per Day)

Dietary of	*Protein in grams*	*Fat in grams*	*Carbohydrate in grams*	*Energy in Calories*
Well-paid mechanics' boarding house	103	152	401	3490
Chemist's family	118	103	430	3210
Jeweler's family	83	117	478	3390
Blacksmith's family	100	171	401	3640
Machinist's family	99	156	421	3580
Mason's family, December 1892	104	148	375	3350
Mason's family (same) May 1893	119	137	348	3190
Carpenter's family	114	135	475	3670
Carpenter's family (second study) November 1892	100	149	388	3390
Carpenter's family (same) May 1893	111	122	336	2965
Research agriculturist's family, Winter 1893	99	139	398	3335
Research agriculturist's family (same) following summer	129	145	472	3800
Students' Club	92	141	343	3110
Standards quoted for comparison				
Voit: Man (German) at moderate work	118	56	500	3060
Atwater: Man (American) at moderate work	125	125	450	3500

BEGINNING OF FEDERAL INVESTIGATIONS OF HUMAN NUTRITION

When Congress in 1894 provided for the study of human foods and nutrition by the United States Department of Agriculture, Atwater was appointed special agent in charge of these "human nutrition investigations."

Under Atwater's inspiration and management a great deal was

accomplished by means of a small Federal appropriation ($10,000 a year at first, and then for some time $15,000 a year).

About half of this money was devoted to work of the most fundamental and meticulously exact character in the energy aspects of nutrition, while the other half constituted a fluid research fund from which small grants-in-aid ("authorizations" to draw upon this Federal fund for a share of the expenses of an approved research project) were made to workers in different parts of the country, chiefly for dietary studies and digestion experiments.

As background for the nutrition research thus being started with governmental recognition and support, Atwater wrote (1895) a bulletin of over 200 pages summarizing the then existent knowledge of methods and results of investigations of the chemistry and economy of foods and (with C. F. Langworthy) a still larger work in which were compiled the results of experiments in which the balance of bodily intake and output had been determined. These were published as Bulletins 21 and 45 respectively, of the Office of Experiment Stations, United States Department of Agriculture.

Atwater's researches of the late nineties appeared chiefly as papers in the annual reports of the Storrs (Conn.) Agricultural Experiment Station and as bulletins of the Office of Experiment Stations, United States Department of Agriculture.

Soon after the turn of the century the newly established Carnegie Institution of Washington began contributing to the support of this work. Later, upon the retirement of Atwater, the nutrition work which had been under his direction was divided between the Carnegie Institution's Nutrition Laboratory in Boston, directed by F. G. Benedict, and the work in charge of C. F. Langworthy in the Federal Department of Agriculture. Results of the Boston Laboratory appeared largely as Publications of the Carnegie Institution of Washington; and those from the Department of Agriculture as bulletins of its Office of Experiment Stations, or, if nontechnical, as Farmers' Bulletins of the Department. The Atwater-Rosa-Benedict type of respiration calorimeter (see Chapter III) was also adapted to work with farm animals by H. P. Armsby, whose compilation

(see Table 4 in Chapter IV) showed very close agreement between observed and calculated calories in the energy metabolism experiments of this period. This agreement justified the development of greatly simplified methods, adaptable both to the "field" type of research and to basal-metabolism testing in medical practice.

The State of Connecticut, whose support of Atwater's nutrition research through its Storrs Experiment Station has been noted above, has also an Agricultural Experiment Station at New Haven. There T. B. Osborne was long and prominently engaged in protein research, which at about the turn of the century was becoming nutritional in character.

Research applicable to the problems of human nutrition was, by the end of the nineteenth century, becoming an increasingly important feature of the work of Agricultural Experiment Stations and Departments of Agriculture as well as in the hands of independent research workers in the colleges, universities, and laboratories devoted to agricultural, medical, and pure science research in several countries.

By the end of the nineteenth century the energy aspect of nutrition and the functioning of the body as a machine were well-recognized concepts, and accurate methods had been developed for measuring energy requirements in people of different age, size, and activity. Also much information had been gathered as to the protein, fat, and carbohydrate contents and energy values of foods and of dietaries.

STUDY OF SIX-DAY BICYCLE RACERS

Nearly at the end of this decade there occurred a special opportunity to study the dietaries and the protein metabolism of men engaged in the exceptionally severe muscular work of an old style six-day bicycle race. These were professional bicycle racers competing in the last of the races in which each rider contested individually, riding as many as he felt able of 142 consecutive hours. Two of the contestants—one of whom finished first and the other fourth among 31 who entered and 12 who finished—were studied continuously as

to hours of work, distance covered, food consumed, and nitrogen excreted. From the findings were computed the amounts of body protein used in addition to the protein derived from the food during the six days of the race. The winner rode a daily average of 20 hours and 1 minute covering an average of 334.6 miles, and contributing an average of 65 grams of body protein per day. The man who won fourth place rode an average of 18 hours and 27 minutes, covering an average of 303.8 miles, and contributing an average of 60 grams of body protein per day. R. C. Carpenter, professor of experimental engineering, Cornell University, estimated the work performed by these men to be of the order of five times the maximum amount expected of men engaged in normal muscular labor. These men showed no signs of injury or disadvantage from having lost 390 and 360 grams, respectively, of body protein during the six consecutive days of the race.[3]

GENERAL VIEW AT THE TURN OF THE CENTURY

From the viewpoint of today, nutritional interpretations at the turn of the century were too narrow in four ways. The body was regarded as more nearly machinelike than it really is; what one could not explain in terms of energy was referred almost exclusively to protein; high-protein diets were assumed as highly desirable on the basis of prevailing opinion rather than of controlled experiment; and considerations of the significance of the growing acquaintance with foods tended toward undue concentration upon considerations of pecuniary economy. The time was ripe for more critical experimental development of the other-than-energy aspects of the science of nutrition in itself, as well as for the use of this science in the advancement of human health and well-being.

Moreover, at this same time Atwater and his co-workers were so developing the precision of experiments with men in the respiration calorimeter as to advance the energy aspects of nutrition to the status of the exact sciences.

[3] The full account was published as Bulletin 98 of the Office of Experiment Stations, U.S. Department of Agriculture, by Atwater, Sherman, and Carpenter in 1901.

CHAPTER III

First Decade of the Twentieth Century Science of Nutrition

AT THE TURN OF THE CENTURY there appeared a very useful and influential book—Robert Hutchison's *Food and the Principles of Dietetics*. Based on lectures given to students of the London Hospital medical school, this book was designed primarily for students and physicians, and was only secondarily for "anyone desiring to acquire some knowledge of foods and the difficult problems of nutrition." The problems of nutrition actually dealt with in Hutchison's book were chiefly concerned with the immediate responsibility of the feeding of patients. This was also the case with another good book published at nearly the same time, *Diet in Health and Disease* by Julius Friedenwald and John Ruhrah, who stated in their preface that they had "tried to tell the doctor how to feed his patient." In treating these aspects of nutrition these two books rendered professional service of great value; and simultaneously the fundamental science of nutrition was actively developed by the research work of this same decade.

THE ENERGY ASPECT

Doctors W. O. Atwater, E. B. Rosa, and F. G. Benedict, working in the laboratories of Wesleyan University at Middletown, Conn., brought the man-size respiration calorimeter to an unprecedented degree of accuracy and delicacy. Descriptions of it were widely published both in this country and abroad, and it came to be recognized by the world of science as constituting a new instrument of precision for researches into the energy transformations of the human body as a whole. At about the time of the completion of this apparatus Dr. Rosa transferred to a position in the United States

Bureau of Standards which prevented his further participation in the work. Atwater and Benedict, aided by grants from the Carnegie Institution, perfected the apparatus still further by development of appliances for the direct determination of oxygen so that even more delicate determinations of carbon and energy balances and of changes in the fat and carbohydrate (as well as of protein) contents of the body could be made. Although the apparatus as thus elaborated was expensive of skilled service to construct and operate, the precise study of energy relations which it made possible was regarded as so fundamental that modified replicas were constructed by Dr. Graham Lusk for use with patients at the Russell Sage Institute of Pathology, by Dr. John R. Murlin for studies of infants at the University of Rochester, and by Dr. H. P. Armsby for studies of farm animals at the United States Institute of Animal Nutrition located at the Pennsylvania State College. As already noted, upon Dr. Atwater's retirement, the work at Wesleyan was divided; the part belonging to the Carnegie Institution was moved to Boston under the direction of Dr. Benedict, while that belonging to the Department of Agriculture was transferred to Washington and placed under the direction of Dr. C. F. Langworthy. From the work of this decade, and the one or two next following, came what is still our most accurate knowledge of the energy needs of human nutrition.

HOW MUCH PROTEIN IS NEEDED AND HOW MUCH IS BEST?

In reporting the early studies of dietaries referred to in the preceding chapter, Atwater expressed his conviction that the dietary studies made in the United States confirmed "the general opinion of hygienists" that our American dietary is one-sided in that we eat too much fat and sugar.

Chittenden [1] agreed that Americans eat too much, but he looked for improvement through "physiological economy" in the consumption of protein—reduction of protein with or without reduction in

[1] See his publications listed in the Bibliography.

fat or carbohydrate, whereas Atwater had accepted the general opinion of the physiologists of his time, that a higher level of protein consumption, at least relatively to fat and sugar, would constitute an improvement in the general American food habit.

Chittenden began a popular magazine article with quotations from Cornaro, Locke, and Francis Bacon, all of whom advocated abstemious food habit. Bacon wrote: "Certainly diet well ordered bears the greatest part in the prolongation of life." Chittenden reasoned that the so-called cravings of appetite are the result of habit, which when it has us in its grasp causes our body to make complaint if its physiological equilibrium is temporarily disturbed by any substantial reduction of our accustomed food intake even though this is so much in excess of real need as to be somewhat hazardous to bodily welfare. Hence Chittenden held that previously proposed dictary standards, based almost entirely on mere observation of what people (of comfortable purchasing power) are in the habit of eating, are of little significance as to real need, tending to be too high, especially in protein. For protein is the part of the diet which tradition and self-indulgence tend most to exaggerate. As against the so-called dietary standards which his studies led him to regard as merely measures of self-indulgence, Chittenden concluded that the ideal diet is that which meets all the needs of the body but with only a moderate margin above what is really needed because anything beyond this quantity is an excess which must inevitably detract in some measure at least from that high degree of efficiency which every enlightened man desires to attain. From this and other statements it is clear that Chittenden regarded a reduction of an unnecessarily high dietary standard, especially as to protein, as not only an economy but also as an improvement of the life process.

In order to ascertain the real needs of normal nutrition Chittenden worked with three types of subjects: professional men, soldiers, and college athletes.

Six professional men ranging from 25 to 47 years of age—university professors and other staff members (including Chittenden and Mendel)—experimented with reduced food consumption for peri-

ods of from four months to two years with determinations of nitrogen balance as well as frequent examinations and observations of efficiency in their accustomed work. The men of the professional group ranged, at the beginning of these experiments, from 146 to 170 pounds of body weight. Chittenden himself, being of small frame, considered his initial weight of 146 pounds to be excessive and counted it a gain in nutritional well-being to reduce his weight to 127 pounds. All these men fully maintained—and some, at least, of them were considered to have improved—their mental as well as their physical vigor on diets in which protein was markedly decreased and total calories not believed to be increased. In 1905 after two years experience with such diet, and again two years later, Chittenden advocated it as distinctly an improvement upon the habit of eating so much protein as was customary and as the generally accepted dietary standards called for.

About 35 years later he told me in conversation that he still followed the low-protein diet and attributed largely to it his good general health and youthful tissue condition at the age of 82. He had found no reason to change his view that a protein intake lower than that of the average American brings "betterment in the physical and mental condition."

In extending his experimental study from mental to physical workers, Chittenden used a squad of soldiers detailed from the Hospital Corps of the United States Army to live at New Haven for six months for the purpose of serving as subjects in this research. The detachment was under the command of Dr. Wallace De Witt, first lieutenant and assistant surgeon in the Army, and maintained strict military discipline throughout. The 13 soldiers who actually served as subjects were from 21 to 43 years of age. These men performed all their regular Army duties and showed gains in well-being upon diets furnishing from 49 to 55 grams of protein per day. Chittenden reported as especially noteworthy the fact that all these soldier-subjects showed "marked gain in bodily strength, as determined by appropriate dynamometer tests" and greater ease and skill in muscular movements. He considered that the results with

these men "all suggest the possible advantages of a daily dietary more closely in accord with the true physiological requirements of the body" than the ordinary American diet with its high protein content.

A part of the fixed conditions of life of these soldiers while serving as subjects in the research, was systematic daily exercise in the university gymnasium under the supervision of the gymnasium instructors.

Inasmuch as it could, of course, be questioned in how far the improvement of the muscular skill and performance of the soldiers could be attributed to their diet and how far to the gymnastic training, Chittenden arranged still another experiment in which the subjects were Yale athletes already trained to high skill in gymnastic exercise and tests, and to prime physical condition, before entering upon the dietary experiments. Chittenden wrote that these men, following the ordinary traditions of training, were at the time the experiment began, consuming at least the 150 grams of protein a day which the then customary standards set as an allowance for men with hard muscular work; but that they experienced no difficulty, when given a low-protein diet, in establishing equilibrium at a much lower level (around 53 to 63 grams of protein a day) and maintaining full gymnastic efficiency on the lower level throughout the five months of the test.

Chittenden emphasized the view that a permanent change to low-protein diet will result in benefit to the health, strength, and vigor and will eventually lead to a betterment of the physical and mental status of the human species.

The full account of Chittenden's experiments with lower consumption of protein than the current dietary standards called for, was published in his book entitled, *Physiological Economy in Nutrition*. In its preface Chittenden suggested that there is open to us the opportunity of a physiological economy in nutrition with the added possibility that health and vigor may be directly or indirectly increased. And that the subject of nutrition, when once it is fully understood and its precepts obeyed, bids fair to exert a beneficial

influence not only upon bodily conditions, but likewise upon the welfare of mankind in other directions.

In the introductory chapter of his *Physiological Economy in Nutrition,* Chittenden raised the question as to how far our instinct can be trusted in the choice of diet, and wrote that our palates are pleasantly excited by the rich animal foods with their high protein content, and that we may well question whether our dietary habits are not based too much upon the mere dictates of our palates in ignorance or defiance of scientific reasoning or true needs. He pointed out that, especially in the case of protein, any excess above what is really needed is not only uneconomical, but may be disadvantageous. And he asked, "Is it not possible that the accepted dietary standards are altogether too high?"

From the viewpoint of 40 years after, it may be said in answer to the question just quoted from Chittenden that the Recommended Dietary Allowances (1941, 1945, 1948 editions) published by the National Research Council and corresponding approximately in function to the so-called dietary standards of the times of Voit, Atwater, and Chittenden, give protein figures for adult maintenance of practically one gram per kilogram of body weight. This middle-of-the-century allowance is thus closer to the recommendations of Chittenden than to those of Voit, of Playfair, or of Atwater.

Chittenden's account of his own experience, especially as to his health and efficiency during his first year on a low-protein diet may be abstracted briefly as follows: In November 1902, he began gradual but steady reduction in his consumption of food and especially of protein. There was no change to a vegetable diet, but a reduction in the amount of meat and other high-protein food. He continued this low-protein diet through the rest of his long life and believed it to be a major factor in the good health he enjoyed in his ninth decade. After a few weeks on the low-protein diet, he reported himself to be unquestionably improved in physical condition. A rheumatic trouble in the knee joint, which had persisted for a year and a half and which previously had only partially responded to treatment, entirely disappeared.

The urine was collected and analyzed almost every day for nine

months. Its nitrogen content indicated an average metabolism of only 36 grams of protein a day.

The low-protein diet was continued both during summer vacation when vigorous exercise was taken and in the regular year of his professional work throughout which he "led a very busy life."

The body weight decreased by almost exactly ten percent during this first year on the reduced dietary, but health, strength, and mental as well as physical vigor were certainly fully maintained and were believed to have been improved. "Greater freedom from fatigue, greater aptitude for work, greater freedom from minor ailments," gradually became associated in Chittenden's mind with the lowered protein intake.

Chittenden's establishment of protein equilibrium in himself at the level of 36 grams a day is by no means the minimum on record. For example, V. O. Siven recorded equilibrium at a protein intake of 25 grams a day, his daily food energy intake being 2747 Calories or 43 Calories per kilogram of body weight.

In his 1905 volume, *Physiological Economy in Nutrition,* Chittenden gives full original records of his experiments with low-protein diet, while his volume of two years later, *The Nutrition of Man,* is a general treatise based on a course of eight lectures delivered before the Lowell Institute of Boston early in 1907. In the preface to *The Nutrition of Man,* Chittenden wrote: "It is hoped that the facts and arguments here presented will help to arouse a more general interest in the subject of human nutrition, as right methods of living promise so much for the health and happiness of the individual and of the community." This hope of Chittenden's has already been justified, and there is promise of much further fruition.

The views of Atwater and Langworthy are now to be considered. In explanation of the liberality of his standards Atwater suggested that the standard must vary not only with the conditions of activity and environment, but also with the nutritive plane at which the body is to be maintained. A man may live and work and maintain bodily equilibrium on either a higher or a lower protein level, or a higher or lower energy level. Here the question is, What level is most advantageous? The answer to this must be sought, Atwater

held, not simply in metabolism experiments and dietary studies, but also in broader observations regarding bodily and mental efficiency and general health, strength, and welfare.

Langworthy, maintaining a similar point of view, collected the data of large numbers of dietaries believed to be fairly representative of the food habits of people of different occupations in the United States and other countries, and stated them in terms of protein and calories per man per day with the results shown in Table 2.

TABLE 2

LANGWORTHY'S COMPILATION OF RESULTS OF DIETARY STUDIES (ABOUT 1900–1907)

OCCUPATION OF HEAD OF FAMILY	FOOD PER MAN[a] PER DAY	
	Protein in grams	*Fuel value in Calories*
United States:		
Man at very hard work (average 19 studies)	177	6000
Farmers, mechanics, etc. (average 162 studies)	100	3425
Business men, students, etc. (average 51 studies)	106	3285
Inmates of institutions, little or no muscular work (average of 49 studies)	86	2600
Very poor people, usually out of work (average of 15 studies)	69	2100
Canada: Factory hands (average 13 studies)	108	3480
England: Workingmen	89	2685
Scotland: Workingmen	108	3228
Ireland: Workingmen	98	3107
Germany: Workingmen	134	3061
Professional men	111	2511
France: Men at light work	110	2750
Japan: Laborers	118	4415
Professional and business men	87	2190
China: Laborers	91	3400
Egypt: Native laborers	112	2825
Congo: Native laborers	108	2812

[a] It was assumed that women consume 0.8 as much food as men, and children of different ages from 0.3 to 0.8 as much as the man of the family.

Langworthy stated that, while the figures given for American dietaries are averages of available data, general averages were not available for other countries, and it was necessary to choose such studies as seemed similar in purpose and method to the American work and which, so far as could be judged, represented usual and normal rather than abnormal or experimental conditions. He concluded that the results obtained, the world over, for persons with moderate physical activity, when figured to a uniform basis of 70 kilograms of body weight, did not differ very markedly from a general average of 100 grams of protein and 3000 Calories of energy and that it is fair to say that, although foods may differ very decidedly, the nutritive value of the diet in different regions and under different circumstances is "very much the same for a like amount of muscular work." It is fair to say that Langworthy's general impression as thus stated, has been confirmed by subsequent research, but also that the most recent investigations reveal that larger numbers of people than the Western World of Langworthy's time conceived are unable to do the "like amount of work" because their national or regional food supplies do not furnish as many food Calories as such an amount of muscular work requires.

In 1907 Chittenden described experiments showing that even so carnivorous a species as the dog needs less protein in his food than is commonly supposed. He emphasized the fact, which still deserves emphasis, that in all species tested, the body has been found to have a relatively elastic storage capacity for surplus protein. But opinions differ as to the advantages and disadvantages of such stores.

Folin experimented with diets of extremely low protein content which, as shown by his nitrogen balances, measurably lowered the protein content of the body; but he considered this a beneficial freeing of the body from the burden of carrying a needless surplus. In effect he wrote that the carrying of a large surplus of fat in the body is generally recognized to be an impediment; and that the carrying of surplus protein "may be none the less so because more common and less strikingly apparent."

In 1907 Howell showed the presence of amino acids in the blood;

and, in well-fed animals, more abundantly in the portal blood than in that of the general circulation, suggesting that the amino acids yielded by food proteins upon their digestion are absorbed into the blood and thus distributed throughout the body. The problem of the body's protein requirement thus began to be a group of problems of its requirements for individually essential amino acids. (This will be discussed in later chapters.) Obviously the concept of a "balanced diet" offers increased possibilities of significance for health and efficiency when we contemplate not only the balances between protein, fat, and carbohydrate, but also the balances (quantitative relationships) between the individual amino acids which food protein yields to the body.

That proteins containing even the same amino acids in different proportions can not be expected to be mutually equivalent in nutrition was, at about the same time, pointed out clearly by T. B. Osborne, from the viewpoint of his long and rigorous studies of the chemistry of proteins.

The protein-sparing action of carbohydrates and fats is also an important factor in the problem of efficient use of protein. In addition to making right choices and combinations of food proteins, still further gains can be effected by using only moderate, instead of high-protein, diets and giving these diets comfortably adequate calorie values by reasonably liberal use of carbohydrates and fats. Earlier work had emphasized the larger protein-sparing effect of carbohydrates than of fats when these are used separately; but in normal mixed diets fats and carbohydrates both spare protein effectively whether there is or is not marked muscular activity and whether the protein level is low or moderately high.

Thus by the use of both fat and carbohydrate, in whatever reasonable amounts and proportions one prefers, one may carry further the economy in consumption of protein in order to use more of one's food money in the purchase of foods of important mineral and vitamin values.

THE AWAKENING TO THE IMPORTANCE OF MINERAL ELEMENTS IN NUTRITION

Howell systematically investigated the influence of salts (electrolytes or ions) on heart muscle, and this field of research was developed along pharmacological lines by Meltzer and Auer, while its significance for normal bodily nutrition in general physiology was pointed out by Moore in the much-quoted statement that proteins in isolation are inert, lifeless bodies: "what puts life into them is the presence of electrolytes" (or their mineral elements and their ions).

Meltzer and his associates showed that the injection of magnesium salts has a marked general inhibitory effect, and that this can be quickly overcome by the subsequent injection of calcium salt. Summarizing the results of extended series of investigations by himself and others, Meltzer stated, in the *Transactions of the Association of American Physicians* for 1908, that calcium is capable of correcting many disturbances of equilibrium in the animal body, whatever the directions of the deviations from the normal may be. He held that any abnormal effect which sodium, potassium, or magnesium may produce, whether the abnormality is in the direction of increased irritability or of decreased irritability, calcium is capable of reestablishing the normal equilibrium.

In the light of the widely differing and sometimes antagonistic reactions of the mineral elements, it is striking to find how widely variable are the intakes in different dietaries. Table 3 shows the maximum and minimum of each of eight elements as found among 150 American dietaries.

Although only calcium, phosphorus, and iron are regarded as likely to become actually limiting factors, it cannot be doubted that maxima and minima so different from each other as these (Table 3) may offer opportunity for adjustments to better balanced proportions and more nearly optimal levels of intake.

Quantitative investigations of the calcium, phosphorus, and iron contents of foods and the amounts of these elements needed in human nutrition, which were begun in this decade, largely by

TABLE 3

RANGE OF VARIATION OF INORGANIC ELEMENTS FOUND IN 150 AMERICAN DIETARIES

ELEMENT	GRAMS PER MAN PER DAY	
	Maximum	*Minimum*
Calcium	1.87	0.24
Magnesium	0.67	0.14
Potassium	6.54	1.43
Sodium [a]	4.61	0.19
Chlorine [a]	5.83	0.88
Phosphorus	2.79	0.60
Sulfur	2.82	0.51
Iron	0.0307	0.0080

[a] Including that of added table salt contained in food as purchased but not the further additions of salt as a condiment.

cooperation of the United States Department of Agriculture and Columbia University, were soon joined by the New York Association for Improving the Condition of the Poor (now the Community Service Society).

The Department of Agriculture in its Miscellaneous Publication No. 546 has explained as follows the reasons for giving special attention to a few, out of a dozen or more, of the nutritionally essential mineral elements.

The body's framework or skeletal system of bones and teeth owes its strength and normal form to the fact of its being well mineralized. Smaller amounts of much more soluble mineral salts are constantly present in the soft tissues and fluids of the body. These facts had long been known, but only with the development of twentieth-century science could they be fully appreciated.

It was about at the turn of the century that Atwater made provision for the study of such mineral elements as calcium, phosphorus, sulfur, and iron as part of the investigation of human nutrition which he was directing. Simultaneously students of the "pure" physical chemistry of physiology were beginning to study the soluble

mineral salts as the things that "put life into" the proteins of the body tissues and fluids.

In our ordinary way of speaking, the chemical elements are the ultimate constituents of which the physical world (living and non-living) is built. Chemists agree in speaking of 92 such elements [2] as things of quite fundamental and ultimate importance to our understanding of the world in which we live. It may therefore seem strange that investigators are not yet entirely agreed as to how many of these elements are essential to our nutrition. This, however, is not difficult to understand and should not be disconcerting. It is simply that there are limits to the delicacy of all laboratory methods; and if the amount of a given chemical element in the body is so small as to be practically at the limit of the chemist's ability to work with it, a doubt may well remain as to whether its presence in our bodies is essential to us or only incidental to its presence in our surroundings. For, a trace of any element that occurs in nature may be accidentally present in the food we eat, the water we drink, or the dust of the air we breathe.

In such a case, then, we may not be entirely certain whether the "trace" element is nutritionally essential or not; yet we may be scientifically justified in the belief that we can safely ignore the element in our dietary calculations because of the evidence that, if any of it is essential to our nutrition, the amount thus needed is so small as to be provided without any planning on our part.

Of the mineral elements concerned in our nutrition, all but four can usually thus be left to chance. These four are calcium, phosphorus, iron, and iodine.

It was recognized before the beginning of the decade here under review that the element sulfur is a factor both in the protein and in the mineral aspect of nutrition. The first Government bulletin in this field dealt with nitrogen, sulfur, and phosphorus in human nutrition. This was followed by one on iron and one on calcium,

[2] This discussion has no need to take account of the additional elements which man has recently made but which are not expected to be encountered in nature, in nutritionally important amounts if at all.

magnesium, and phosphorus. Each of these three bulletins included a review of previous work in its field and an original report of experimental research. The second and third included also new and compiled data on the iron, calcium, magnesium, and phosphorus contents of foods, and computations of the amounts of these elements in typical American dietaries, such as those summarized in Table 3. Comparison of these computations upon dietaries with the tentative indications as to the quantitative requirements for mineral elements in human nutrition furnished guidance for the planning of the further research upon calcium and phosphorus requirements which played an important part in the nutritional progress of the next two decades. The relationship of iodine to the prevention of simple goiter was fully established at a slightly later time.

DAWN OF THE ERA OF DISCOVERIES OF VITAMINS

In 1906, Professor (later Sir) Frederick Gowland Hopkins of Cambridge University announced to a group of professional food chemists in London—and through their journal (*The Analyst*) to the world—the existence of some substance or substances not previously known but essential to nutrition. Calling them by the over-modest name of *food accessories* he stated clearly that one or more of such substances is needed for the support of normal growth and for the prevention of scurvy and other "deficiency" diseases. These substances came to be called *vitamins*. The discovery of their existence, and of the nature of the previously baffling deficiency diseases, was a most important milestone in the progress of nutrition "as a science in itself and as an instrument of social policy" and human welfare.

The case of the vitamins illustrates well the important but oft-forgotten fact that a scientific discovery need not be the work of a given person at a given time. Often it involves a gradual accumulation of evidence (sometimes contributed by different people working at different times and places) until finally it becomes convincing. Even then, one may ask, Convincing to whom? To those who knew the quality of Hopkins' experimental work and the carefulness of

his communications, his announcement of 1906 was sufficiently conclusive, while others may not have been fully convinced until his publication of the details of his evidence in 1912. And in the meantime there had been other contributions of evidence from several workers in different parts of the world which added much to the convincingness of what we may call the vitamin concept. In fact, in the light of later knowledge it has been possible to interpret as evidence of vitamins some observations made even earlier than those recorded by Hopkins in 1906; but, at least for the English-speaking world, the effective "discovery of vitamins" may, in the opinion of the present writer, most properly be attributed to Hopkins and dated from 1906. His approach was primarily through experiments in normal nutrition, while Dutch investigators in the East Indies by a more medical kind of research were approaching the same general concept at essentially the same time. Here again, assignment of a date to their nutritional discovery is difficult because, as a British committee later expressed it, the earlier Dutch studies of beriberi were reported "with so strong a pharmacological bias" that their nutritional significance was not made apparent at the time. It was in 1906, the same year in which Hopkins made his announcement, that the Dutch investigators began clearly to interpret beriberi as a nutritional deficiency disease. Much earlier than this it had been stated in medical writings that scurvy could be prevented by eating fresh fruits or green vegetables; and attention to the frequent replenishment of their supplies of these fresh foods, when renewing their water supplies at the coasts they visited, had contributed to the success of some of the voyages of discovery including those of the famous Captain Cook. And in 1841 G. Budd had moved forward the concept of an antiscorbutic *property* to that of a definite, though not yet isolated, *substance*.

In the first decade of our century Holst and Frölich were working with experimental scurvy in guineapigs.[3] This was a quarter of a century before King's identification of the antiscorbutic vitamin,

[3] Guineapig is now preferably written as a single word to mark it as scientifically a misnomer.

yet it was about a century after the British navy had eradicated scurvy from its sailors by the regular issue of citrus fruit juice as a part of their rations. This reform soon spread to the merchant marine and so the British had effected a nutritional improvement in the life of an important part of their population long before the physical isolation or chemical identification of the nutrient substance concerned.

Much further light upon the vitamins and their importance to nutrition was to come in the next following decades.

With the awakening to the importance of individual amino acids and mineral elements in nutrition and the discovery that natural foods contain, and normal nutrition requires, other substances, the very existence of which was previously either entirely unknown or only dimly apprehended, science arrived at a workable scheme, the clear conception of which was celebrated in the general adoption of the phrase which McCollum, in 1918, made current by use as the title of his book, *The Newer Knowledge of Nutrition.*

It is worth repeating that this "newer" knowledge supplements and does not supplant the older knowledge of nutrition, and also that the advent of the newer knowledge did not occur all at once. Moreover, to a large extent the second quarter of the twentieth century teaches much the same practical dietetics as did the first quarter; but with increased emphasis because of increased knowledge.

People born into nutrition-conscious families in recent years will have had greater advantages in this respect than those born earlier. But one cannot set any one year, or even any one decade as marking the boundary between the older and the newer era in this field. And knowledge regarding, for instance, any one vitamin was not always won in the traditional chemical sequence of qualitative first and quantitative afterward. Foods were compared quantitatively as to their vitamin A, B, and C values, and the extents to which these were impaired under given conditions of heating, or keeping, before any one of these vitamins had been physically isolated or chemically identified.

As rapidly as pure specimens of vitamins were sufficiently available, "vitamin assays" of foods were conducted in strict parallel with the pure substance and the results stated in those terms; but before the pure substances were thus available, much quantitative work of both immediate and permanent value to dietetics had been done, and recorded in terms of the relative potencies of foods compared with each other, either directly or through measured responses of standardized test animals. Thus the nutrition-conscious people could so choose their dietaries as to enhance their vitamin values. Moreover, by experiments with properly chosen and controlled test animals, one could compare the effects of relatively higher or lower intakes of a given vitamin even before the exact chemical nature of the vitamin was known.

CHAPTER IV

Nutrition in the Decade of 1911–1920

THE YEARS FROM 1911 TO 1920 saw important progress of knowledge through research (sometimes retarded, sometimes accentuated, by the First World War) in each of the four major fields of nutrition—the energy aspect, the proteins with their amino acids, the mineral elements, and the vitamins. To sketch this progress in the space of a chapter of moderate length will require omission here of all except what seems to bear most directly upon the problems of nutritional need and the advancement of nutritional well-being.

THE ENERGY ASPECT

We have seen that it was at about this time that the most accurate measurements of the energy needs of nutrition were made. When the energy given out by the body as activity and as heat is measured by the respiration calorimeter (development of which was described in the preceding chapter), the total energy output expressed as heat agrees very closely with the heat obtainable by burning the same amounts of the same fuel nutrients in the bomb calorimeter used in measuring the energy values of foods.

In 1913 Dr. H. P. Armsby brought together all the then available data of such comparisons, with carnivorous and herbivorous animals and with men. The results are shown in Table 4.

It will be seen that in each of six series of such experiments the agreement of heat production as computed and as observed was within less than one percent, while the totals differ by only about one quarter of one percent. This is so well within any reasonable allowance for experimental error that the computed and observed calories are regarded as substantially identical. Or, as it is also ex-

pressed, the findings of direct and indirect calorimetry are interchangeable.

And from the universal acceptance of this view there has followed the practical result that, except for very special research problems, one need no longer use the costly and delicate apparatus and methods of direct calorimetry but may compute the calories from the observations made with relatively inexpensive and easily portable respiration apparatus.

TABLE 4

ARMSBY'S COMPARISON OF ENERGY COMPUTED AND FOUND

Experimenter	*Total number of days*	*Total computed heat production in Calories*	*Total observed heat production in Calories*	*Percentage difference*
Rubner	45	17,406	17,350	−0.32
Laulanié	7	1,865	1,859	−0.31
Atwater and Benedict	93	249,063	248,930	−0.05
Benedict and Milner	24	95,075	95,689	+0.65
Benedict	53	102,078	101,336	−0.73
Armsby and Fries	114	976,204	980,234	+0.41
	336	1,441,691	1,445,398	+0.26

Such apparatus is now used in nearly every hospital and in many individual doctors' offices, as a means of diagnosis and of following the progress of the disease and the convalescence wherever the basal energy-exchange is affected. Thus the taking of the basal metabolism has become almost as familiar as the taking of the pulse.

Moreover, the portable forms of respiration apparatus make possible the study of the energy aspect of nutrition in many kinds of experimental and field research. Thus any abnormal condition of the energy aspect of nutrition can be promptly detected and its cause dealt with accordingly.

And by the same methods one may study the "energy cost" of any definable form and degree of bodily activity or environmental condition.

In such diagnoses and investigations one deals with differences so much larger than the one quarter of one percent which Armsby found between the energy computed from the chemistry of the respiration and that directly observed as heat (Table 4 above) that the interchangeability of "direct" and "indirect" calorimetry or measurement of energy exchange is abundantly established for such practical purposes as have been mentioned.

In some other connections, however, there may be a very real interest in the fact that, in Armsby's careful and comprehensive comparison of the data, the amount of heat production directly observed was one quarter of one percent more than the amount computed by the chemical accounting for the nutrient fuel oxidized. If this be taken as a real difference (even though so small as to be negligible in the estimate of the amount of energy the body transforms in meeting its needs) it is in the direction which makes sense; and it stimulates a legitimate scientific curiosity in that it suggests some form or forms of energy entering the body which are different in kind—and so, perhaps, in function—from the food-calories. We know, for instance, that the body makes use of a little of the light energy which impinges upon the skin and especially upon that highly elaborated skin-spot which constitutes the eye. Thus the eminent psychologist E. L. Thorndike suggested that the light reflected into the eye from the page as one reads may supply the energy transformed by nerves and brain in transmitting and interpreting what we read. If so, this light energy used in seeing (while amounting to so little compared with the food energy as to be only doubtfully measurable) may yet be important to us in that it permits us to read. And it may have been equally important to our pre-reading ancestors in that by seeing they were enabled to escape their enemies and to find their food.

More recently, we have also learned that a part of the light energy impinging upon the skin when any part of the body is exposed to direct sunshine is usefully transformed in promoting the chemical reaction by which vitamin D is formed in the skin, whence it is distributed to other parts of the body.

Yet important as these other forms of energy may be in special functions, their total compared with the body's total energy need is either too small to measure, or, if regarded as unwittingly measured in Table 4, is only of the order of magnitude of 1 part to 400 parts of food energy.

Energy aspects in practical medicine are well illustrated by the work of Dr. Warren Coleman and Dr. Eugene F. DuBois regarding the influence of the high-calorie diet on the respiratory exchanges in typhoid fever.[1] They confirmed the accuracy of the Benedict (portable) "universal respiration apparatus" and found it well adapted to clinical use. While fever causes an increased rate of oxidation and therefore a higher food-energy requirement for equilibrium than in the normal body, their typhoid patients tolerated high carbohydrate diets well, and by liberal use of such diets they could bring the patient into protein and weight equilibrium. In typhoid patients thus liberally fed, it appeared "that the regenerative processes of convalescence begin before the temperature reaches normal."

While in general the scope of this book does not include medical questions, it is appropriate to note this illustration of the fact that the newer knowledge of nutrition serves the maintenance of better nutritional status both in health and in disease and convalescence.

ADVANCES INVOLVING BOTH ENERGY AND PROTEIN

A. E. Taylor, trained both in medicine and in biochemistry, and enjoying an exceptional opportunity for the study of world food problems as one of the directors of the Food Research Institute at Stanford University, frequently said that "whereas in other countries the population presses on the food supply, in this country the food supply presses on the population." It was and still is a scientifically sound question whether in a country whose food supplies and resources for food production are as large per capita as ours, a significant proportion of the people may be tempted into over-

[1] *Archives of Internal Medicine*, 14 (1914), 168–209.

eating and overweight. A generation ago it was perhaps even more common than now to challenge thought by suggesting that "we all eat too much," or that in this country there is more danger to health from overeating than from undereating. Even though they recognized that only a minority become conspicuously obese, and although they were mindful of those who live in dire poverty, it was nevertheless believed by many that in the earliest years of the twentieth century a majority of Americans ate more than was best. Atwater would have reduced specifically the consumption of fat and sugar and Chittenden would have reduced the consumption of protein; but both of them and their followers believed that the best food habit would be somehow more accurately adjusted to actual need, than that of the average American of the generation preceding the First World War. Almost axiomatically, physical training was taken to mean "training down." Hence our participation in the First World War brought into full consciousness the question whether Americans could reduce their accustomed level of food consumption thereby bringing about either a gain in their working efficiency, or an increase in the amount of food that could be spared for shipment to our Allies, or both.

F. G. Benedict, W. R. Miles, Paul Roth, and H. M. Smith attacked this problem. The subjects were healthy young to early-middle-aged men, students and staff members of the Training College at Springfield, Massachusetts. They ate restricted amounts of a well-balanced diet, thus receiving moderate intakes of protein with less than sufficient food calories for maintenance of body weight, until the initial body weight had been reduced by 12 percent during a period of from 3 to 10 weeks. During this time there was also a diminution of the basal energy metabolism per unit of body weight. The combined effect of the two reductions (in body weight and in rate of energy expenditure per unit of weight) was to bring the total energy expenditure from an initial rate somewhat over 3000 Calories to the reduced rate of a total expenditure averaging 2075 Calories (with about 60 grams of protein) per man per day. Thus

there was a total reduction of about one third in the the average food consumption where the average reduction of body weight was about one eighth. On this lesser amount of food (and with this reduced body weight) the men remained healthy and continued to perform their accustomed work. From the viewpoint of these facts alone it could be considered that there was here a large gain in efficiency in that the same work was accomplished at an energy expenditure only two thirds as large. But there remains some question as to how much of this was a true saving resulting from more efficient exertion, and how much was the result of the reduction in the amount of energy which each man called upon his body to exert. This latter might mean that the men were, in Atwater's phrase, living on a lower energy level or plane. Benedict and Roth reported that "the actual output of heat during sleep" was reduced by about one fourth, with the apparent implication that one fourth rather than one third might be a truer interpretation of the actual saving of energy. Smith found "a marked saving" (amounting to 8 percent after 20 days, and 14 percent after 4 months) "in the energy requirements for walking in favor of the reduced diet." And Miles reported from his neuromuscular and psychological studies of these same men that in general it must be concluded that the prolonged reduction of diet (in the degree already described) produces some decline in neuromuscular activities, but this does not seem nearly as definite nor as large as the change in metabolism and allied measurements. The psychological changes were in Miles' opinion not such as to interfere materially with a satisfactory discharge of the common duties of student life.

From the findings as a whole it would appear that, for these students and college staff members, the golden mean of optimal efficiency in the use of dietary calories lay somewhere between the original liberal level of 3000 to 3600 Calories a day and the level of only 2200 Calories a day on which, with the same responsibilities, they did their work and kept their health although they experienced some lowering of animal spirits and neuromuscular activities.

OF RELATED INTEREST

T. B. Woods, professor of agriculture in Cambridge University, in a booklet written during the First World War, explained how expensive of food resources is the feeding of grain to meat animals and especially the fattening of beef animals by intensive grain feeding. In and after the Second World War these principles found still wider application. Their consistent use, saving grain for conversion into bread and milk, could be made a great step toward eradication of malnutrition. Each consumer's market demand may help toward this great nutritional improvement.

FOOD PROTEINS AND THEIR AMINO ACIDS

Osborne and Mendel found that rats fed upon rations comparable in every way can be maintained in body weight with a smaller intake of lactalbumin than of any other of the numerous proteins they studied. Lactalbumin also showed high supplementary value in mixed rations. Casein, the other chief protein of milk, is also both highly nutritive in itself and very efficient in supplementing the proteins of grain products.

Other experiments during this decade indicated that the proteins of wheat, oats, and maize have nearly the same nutritive value for adult human maintenance. Moreover, they are all so effectively supplemented by milk protein that when nine tenths of the protein of a dietary comes from one or more of the cereals (or the staple breadstuffs made from them) and one tenth from milk, the nutritive value of the protein of such a combination is as effective as that of the average American mixed diet. As the milk used primarily to supplement the bread and cereal proteins also makes other important contributions to the diet, the high nutritive values of the combinations of milk and grain products makes it easy to economize in the use of the more expensive forms of protein and thus provide the means to purchase more of fresh vegetables and of fruits. These same experiments also showed that with dietaries properly "built around bread and milk" the amount of protein

needed for adult maintenance is rather lower than had been supposed, even from the work of Chittenden. The usual allowance of one gram of protein per kilogram of body weight per day for human adults other than pregnant and lactating women has been restudied independently by H. B. Lewis, and experimentally by F. J. Stare and his co-workers. From both of these studies this allowance appears to provide a margin of from 50 to 100 percent more than the actual need.

The interpretation of protein need in terms of individual amino acids, and the relative nutritive values and supplementary relationships of the proteins of different types of food will be discussed in later chapters.

"BALANCED" DIET OR FOOD SUPPLY

Before the decade here under review, farmers used the term balanced ration with reference only to the relation between proteins on the one hand and carbohydrate plus fat on the other; while some held that the feedingstuffs used should not all come from the same species of plant. Thus there arose a "rule of thumb": Make the balanced ration by using materials from three kinds of plants.

Dr. S. M. Babcock of the University of Wisconsin inspired an investigation by Hart, McCollum, Steenbock, and Humphrey in which a ration balanced in the then prevalent sense and made up of materials from the corn (maize), wheat, and oat plants, was tested against three similarly balanced rations each made exclusively from some one of the plants. Each of these four rations was fed to a group of four young cows, all of which were allowed the same amount of exercise in a lot free from vegetation, and were permitted to lick as much table salt and drink as much water as they wished.

The four groups ate about the same amounts of their rations, digested them equally well, and for a relatively long time all seemed to thrive; but, gradually, pronounced differences in nutritional condition developed which were regularly related to the rations fed.

These differences showed that the ration made from all three plants was not in this case the best.

The corn-plant ration proved the best; the wheat-plant ration the worst; the oat-plant ration and the three-plant ration both giving intermediate results. The animals on the corn-plant ration were sleek and fine, healthy and vigorous; those on the wheat-plant ration became rough-coated and gaunt, and prematurely old and feeble.

Each ration contained, of course, both grain products and stem-and-leaf parts of the plant. Supplementary experiments showed that the nutritive values of the grains were fairly similar, but those of the other portions of the plant were very different. The leaves and stem of the corn (maize) plant have somewhat the nutritive properties of a green vegetable, with high vitamin A value and good calcium and general mineral content, while wheat straw is almost devoid of such food values. When wheat grain was fed with corn leaves, or with alfalfa hay, the results were good. Evidently the older conception of a balanced diet failed to take account of factors which are of absolutely essential significance even when dealing with familiar foods and feedstuffs.

Experiences such as these convinced chemists of the importance of supplementing food analyses by investigation of the more elusive factors of food value through employing as a means of chemical research the nutritional reactions of the living body as a whole.

And this use of the whole living body as a "reagent" should sometimes be continued throughout whole lifetimes and even into successive generations of the experimental animals.

Returning to the above-mentioned experiments with cattle in the light of the newer knowledge of nutrition, the Wisconsin experimenters were able to show that the deficiencies of the wheat-plant diet, for which they had originally compensated by adding green leaf foods, could also be corrected by the addition of bone meal and codliver oil. Thus the explanation was found in terms of the mineral elements and vitamins, and, in this case, more specifically in terms of calcium and vitamin A (perhaps also vitamin D). We shall find these factors playing prominent parts also in the

problems of adequate human nutrition under those restrictions of food supply which poverty sometimes imposes.

Here, and again in the case of vitamin C, the nutritional discoveries of the decade from 1911 to 1920 brought very direct guidance for the bettering of human food habits. The fact that many people followed this guidance—and doubtless to their gain in nutritional well-being—is seen by the increased per capita consumption of fruits, milk, and vegetables since about that time.

In 1917 McCollum, Simmonds, and Pitz clearly stated the importance of leaves in making good the nutritional shortages in seeds. The nutrients involved in terms of the knowledge of that time were chiefly calcium and vitamin A value. McCollum called "protective" those foods which he found rich in both calcium and vitamin A value. Later knowledge shows that in addition, the seed is relatively poor and the leaf relatively rich in riboflavin.

In 1915 Osborne and Mendel had found that after long-continued failure to grow, due to shortage of some essential nutrient, good diet may result in a resumption of growth. The resumed growth may even be as rapid as, or more rapid than, normal growth at the same size. This deserves emphasis because many people have hitherto assumed that any suspension of growth means "irreparable injury." Osborne and Mendel's findings, by pointing out the more optimistic possibility, have doubtless done much for nutritional rehabilitation of children for whom formerly it would have been thought hopeless.

FURTHER STUDIES OF THE FATE AND FUNCTIONS OF PROTEIN

There is much experimental evidence that the average American could reduce his consumption of protein by one quarter to one half and continue to do his accustomed work just as well, or, as Chittenden and Folin believed, perhaps better in long-time experience. If one regards the prospect of direct improvement of nutritional status through reduction of protein as remote, there is still interest in knowing how the proteins and their amino acids function in our nutrition.

Chittenden's work in this field, and some of Folin's, was reviewed in the preceding chapter, where also we noted Howell's finding that the amino-acid digestion-products of the proteins circulate normally in the free state (as well as recombined to form blood proteins) in the blood. For a time it was questioned whether the amino acids found in the blood existed normally in the free state in live blood or whether they were liberated in the process of analysis. This question was settled very ingeniously and convincingly by Abel, Rowntree, and Turner who developed a method and apparatus for dialyzing the circulating blood of a live animal against a fluid so constituted as to maintain the blood in other respects while allowing a part of any *free* amino acid (contained in the blood at the time) to dialyze out.

Several laboratories contributed to the experimental working out of the modern view that food proteins are normally digested all the way to amino acids, which are absorbed and distributed as such in the body. Each tissue thus receives free amino acids with which to build body proteins of its own pattern. Thus, simultaneously but independently and using different methods, Folin and Denis, Osborne and Mendel, and Van Slyke and Meyer all threw light upon the processes involved.

In their studies of protein metabolism from the standpoint of blood and tissue analysis, Folin and Denis reasoned that the level of nonprotein nitrogen of the blood must be a more or less sharp indication of the efficiency of the kidneys in removing the waste nitrogenous products circulating in the blood. This general principle had been discussed by others before them, but inconclusively. Now, by the use of new analytical methods which were developed for this particular purpose, they were able to measure degrees of retention of these nonprotein nitrogenous end products with much greater accuracy and conclusiveness than had previously been possible. Using these improved chemical methods they found strikingly constant levels of these waste products in the blood of perfectly healthy men of from 20 to 45 years of age; but higher results were obtained when they worked on the blood of patients. Among

those people clinically regarded as nephritic, the amounts (concentration levels) of nitrogenous waste products in the blood was nearly always much higher than in corresponding blood samples from healthy people. Folin and Denis considered that the urea and total nonprotein nitrogen in the blood must in the main be inversely proportional to the general efficiency of the kidney since the kidney represents practically the only outlet for the nitrogenous waste products. McCollum, in his discussions of these and other findings of Folin and his co-workers, has suggested that there may be a noteworthy significance in the fact that some men retain as good youthful efficiency in this respect at 45 as at 20, while on the other hand a decline of efficiency in the kidney may occur at unduly early ages in a larger proportion of American people than are regarded as nephritics. Are such differences inherited, or are they the results of food habits? Perhaps both genetic and nutritional factors play a part in this aspect of the problem of unduly early aging *versus* the conservation of the characteristics of youth. The combined evidence of human experience and controlled laboratory-animal experimentation shows conclusively that food makes a difference but does not yet show us how to assess the relative potencies of the genetic and the nutritional factors.

Returning to the place of the proteins in the problem of optimal human nutrition, while the work of Chittenden and of Folin showed convincingly enough that relatively low levels of protein consumption are adequate for healthy human maintenance, it was being found at the same time that some food proteins have quite different amino-acid makeup from others and show correspondingly different nutritive values in experiments in which proteins are fed singly. But this condition ordinarily exists only in research laboratories. There, it has value in working out fundamental knowledge, and has even guided research to the discovery of nutritionally essential amino acids whose existence was previously unknown. Under ordinary conditions of human life, however, our daily food always contains several kinds of proteins which tend to equalize the differences of each other's amino-acid contents so that one need

not add any further margin for safety to such low-protein diets as those of Chittenden, for example.

Hence, when the British in the course of the First World War began to feel the need of national food planning, their most eminent physiologists could join in the public teaching that: "If we can take care of the calories, the proteins can take care of themselves." Later it has been found, as well emphasized by Youmans and others, that in times and places of severe food shortages, the symptoms of protein deficiency are apt to appear only when energy (calorie) deficiency also exists.

MINERAL ELEMENTS

Recognition of the importance of mineral elements in our nutrition was, as explained in Chapter III, one of the features that combined to mark the era of the newer knowledge of nutrition as beginning with the twentieth century. In the second decade of the century the work on mineral elements was continued. The balance of acid-forming and base-forming elements was studied. Investigations of mineral elements as factors in the health problem of the adequacy of American dietaries were, in cooperation with the New York Association for Improving the Condition of the Poor (now the Community Service Society), carried on, in Columbia and other universities, into the period of the First World War and put to service in its nutrition problems and those of its aftermath.

In the study of acid-base balance it was found that acid-forming elements always predominate in meats, fish, poultry, and eggs and in lesser degree in grain products. Fruits and vegetables with few exceptions showed a predominance of base-forming elements, as also does milk in a lesser degree. When the acid-forming elements predominate in the diet as a whole, its oxidation in the body yields surplus acid—"fixed" acid which, unlike carbonic acid, cannot be thrown off through the lungs. Sherman and Gettler found that, of this surplus fixed acid, elimination as ammonium salt (the usually cited mode of disposal) accounted for only about one third, and the acidity of the urine only about another third. The remainder pre-

sumably was excreted in three ways (none of which was precisely measured): as acid through the skin, as acid through the intestine, and as a salt of a fixed base withdrawn from the body's alkaline reserve. It is not difficult to postulate that these five modes of disposal will together take care of the surplus fixed acid almost as rapidly as it is produced. The difficulty is to decide whether when the surplus is thus disposed of, the body is just as well off as it would have been if the diet had been so chosen as not to introduce any surplus fixed acid to draw upon the alkaline reserve. On this "the doctors disagree." Perhaps the majority of them regard it as a matter of little, if any, concern. Doubtless also those physicians who do think it worthwhile to use diets in which acid-forming and base-forming elements are sufficiently balanced, so that little if any surplus fixed acid is produced in the body, are the ones who have given most careful study to the subject. Ragnar Berg made use of the concept of acid-base balance in connection with fasting treatments essentially as follows. The tissue which the body oxidizes in fasting gives rise to more (fixed) acid than base, and this surplus fixed acid must be taken care of in one or more of the ways mentioned above. This oxidation of tissue is minimized so long as the body has available other fuel nutrients (carbohydrates and fats); but when the carbohydrate is exhausted, and tissue oxidation sets free relatively much acid and little base, Berg feels that this may add seriously to the acidosis which tends to develop from incomplete oxidation of fatty acid when the body's fat-burning "mechanism" is overworked. He therefore advises that base-forming diets be used on the day before, and throughout, a fasting treatment, and that a diet in which base-forming elements predominate should be continued in the post-fasting period.

While the use of diets in which base-forming elements predominate (or which keep the urine neutral or nearly so) is certainly not to be regarded as a cure-all, it is a habit that probably often does good in the long run unless it is allowed to absorb so much attention as to make one negligent of other things. Dr. Peyton Rous has found that whereas nearly all studies of acid-base balance in the

body relate chiefly to the influence of the blood or to the balance in the blood, there are cases to which he applied the term *outlying acidosis* in which the acid products produced in certain parts of the body are not brought so quickly under the full influence of the blood as other students of the subject have tacitly assumed. Thus there may be more benefit to the body in taking account of the acid- or base-forming character of the food than the majority holds at the present time.

The studies during the decade here under review upon calcium and phosphorus are noteworthy. By the end of this decade, expectations of special nutritional virtues in particular organic compounds of phosphorus had been largely outgrown, and in assessment of the adequacy of the phosphorus factor in food supplies it was deemed sufficient to compare the total phosphorus of the food with the amount needed for maintenance of equilibrium in adults or of a normal rate of retention of phosphorus during growth. In 95 balance experiments of such character as to throw light upon the maintenance requirement, the average minimal need appeared to be 0.88 gram of phosphorus per 70 kilograms of body weight per day. In 224 presumably typical American dietaries only 8 showed phosphorus contents less than this; and if the dietaries of less than 3000 Calories per man per day had been raised to that level without change in character only 2 in 224 would have contained less than 0.88 gram of phosphorus per man per day. Thus ordinary American dietaries almost always contain enough of phosphorus (as they do of protein). Calcium is, however, much more often a limiting factor (Sherman, 1947).

Hence calcium will enter more often than phosphorus into our subsequent discussions of improvement of nutrition through better choice of food.

"PROTECTIVE FOODS"

McCollum's extended feeding experiments with different types and combinations of foods showed that calcium is often the limiting factor; or one of two such factors, of which the other is vitamin A.

He coined the term *protective foods* for milk and the green leaf vegetables, which are good sources of both calcium [2] and vitamin A. People influenced by McCollum's teaching increase their consumption of protective foods which enriches their dietaries in calcium and in vitamin A value at the same time. Many careful comparisons of the calcium contents of American diets with the calcium needs of human nutrition, as found by calcium balance experiments with man and full-life experiments with animals, indicate that our national dietary becomes better able to support a high level of health when we increase its calcium content. And other evidence makes it highly probable that this is also true of the vitamin A values of a large proportion of our dietaries. Often, therefore, the improvements wrought by these two nutrients are so blended that we cannot discriminate between them with certainty, yet they are no less important on that account.

VITAMIN A

Evidence of the existence of some nutritionally essential fat-soluble substance or substances, different from those previously known, came in 1913 almost simultaneously from McCollum and Davis, and from Osborne and Mendel. The first such substance to be clearly differentiated is the one we now know as vitamin A and recognize as essential to the life process at all of its stages. Recognition of its significance, and of the importance of providing for liberal amounts of it in our dietaries, is one of the major advances of the science of nutrition. It is undoubtedly a very important factor in the nutritional improvement of life processes and so of life histories.

Osborne and Mendel having recorded finding the same property in egg fat and in codliver oil as in butter, suggested in their discussion that perhaps this fat-soluble substance may be the key to "a clearer understanding of the physiological potency of natural prod-

[2] Except that the calcium of the leaves of the Goosefoot family, including spinach, chard, and beet greens, is not nutritionally available. Leaves of broccoli, collards, kale, loose-leafed lettuce, and turnip tops are among the greens which are excellent sources of both calcium and vitamin A.

ucts like butter, egg yolk, and codliver oil, which have long enjoyed a popular, yet inexplicable, reputation for unique nutritive potency."

Osborne and Mendel, and also McCollum, found that shortage of this fat-soluble substance resulted in a characteristic eye disease in their experimental animals. In 1919, 1921, and 1924 Bloch published full accounts of this disease which became prevalent among children of the Danish poor during the butter shortage of the First World War.

McCollum also emphasized this "fat-soluble A" as functioning importantly in the building of health from merely passable to higher levels.

While there are some questions still open regarding the relation of vitamin A to disease, its relation to positive health is quite certain. Even in 1918 McCollum connected it with greater longevity and success in the rearing of young; and this positive knowledge has been much strengthened and extended by subsequent research to be discussed in a later chapter.

"VITAMIN B"

The substance identified by R. R. Williams and his co-workers, whose long series of papers was summarized and fully discussed by Williams and Spies in 1938, was renamed *thiamine* to indicate as much of its chemical nature as could be suggested by a single short word. It is also sometimes called *aneurin* to suggest its function in the prevention of *neuritis*; or *vitamin* B_1 to indicate that it is the senior of a series of substances all of whose functions (so far as then known) were originally attributed to a postulated substance called *vitamine* or beriberi vitamine by Funk, *water-soluble B* by McCollum, and *vitamin B* by Drummond.

In the present chapter, we are immediately concerned with the undifferentiated vitamin B as conceived in the decade from 1911 to 1920. It was early found to be essential for the growth of the young, and for health at all ages.

The effect of this factor in preventing the nerve disease beriberi

(*multiple peripheral neuritis*) had been studied pharmacologically since 1897, but not brought into the form of a clear-cut nutritional concept until 1901 or 1906, according to the extent to which we interpret the publications of that period in the light of later knowledge.

Drummond's term *vitamin B* was equally the name of this substance whether studied as a factor in normal growth or in the cure and prevention of beriberi.

In 1907 W. L. Braddon published in his book, *The Cause and Prevention of Beriberi,* a large amount of clinically observed evidence connecting the disease with the eating of polished rice.

Of evidence collected under conditions more like those of a controlled experiment, that of K. Takaki of the Japanese Navy has been cited so often as not to need retelling here. Less familiar but equally instructive was the work of H. Fraser and A. T. Stanton, who in the course of carrying on a road construction project, took 300 laborers from Java into new and sanitary quarters in a virgin jungle and demonstrated in striking fashion under strictly controlled conditions that, with rice as the main part of the diet, beriberi followed the use of polished but not of unpolished rice.

Among many other evidences from human experience of the relation of diet to the prevention of beriberi, previously very prevalent in the Orient, we here cite only that of Chamberlain, one of the American Army officers serving in the Philippines after the Spanish-American War. In the force of about 5200 "Philippine scouts" there had been 618 cases of beriberi in 1908 and 558 cases in 1909. In 1910 the ration was changed and the number of cases of beriberi dropped to 50. In the next three and one half years with the reformed diet there were a total of only 6 cases reported and these may have been the result of the men not eating the protective foods that were issued to them.

In growth experiments made chiefly with rats it was found that, on diets otherwise adequate but lacking vitamin B, young animals cease to grow, usually sooner than on diets lacking vitamin A.

Doubtless the chief reason for this difference lies in the fact that

the physical and chemical properties of vitamin A permit of its storage in the body for longer times, and in quantities relatively greater as compared with daily need, than in the case of vitamin B.

When animals are kept on a diet adequate in other respects but lacking vitamin B, they lose appetite, lose weight, and develop a condition of general weakness with more or less distinct polyneuritis. The process of digestion is also impaired, especially through a general decline of tone in the musculature of the alimentary tract. McCarrison found that different species show generally similar symptoms and increased susceptibility to miscellaneous infections in vitamin B deficiency. Among the symptoms which McCarrison observed in his vitamin-B-deficient monkeys were: loss of appetite, diarrhea, subnormal temperature, progressive anemia, enfeebled heart action, and (usually late in the sequence of symptoms) distinct neuritis.

We shall return in later chapters, and in the light of the advances of knowledge since 1920 to the further consideration of the part played by vitamins of the B group in the improvement of our mental and physical lives.

Pellagra

It is very significant that important advances in the nutritional improvement of hundreds of thousands of human lives had already been brought about through scientific research in which natural foods, as distinguished from chemically individual substances were the experimental variables,' before the preventive substance was identified. There was also very clear experimental evidence of the production of pellagra in man by controlled feeding of a diet such as had been widely used in the regions where this disease had been prevalent.

Goldberger and Wheeler reported this experimental production of pellagra in white male convicts who volunteered for the experiment on promise of a pardon upon its completion. It was performed at the Rankin farm of the Mississippi penitentiary and is often referred to as the Rankin farm experiment. Eleven men were subjects.

All other persons resident on the farm were under observation as controls. The subjects ate from 3500 to 4500 Calories of food containing from 90 to 110 grams of protein, 95 to 135 grams of fat, and 540 to 580 grams of carbohydrate, per day. Between 20 and 35 percent of the protein was of animal origin. The foods used were: highly milled wheat flour, maize meal and grits, cornstarch, cane sugar, cane sirup, sweetpotatoes,[8] fat pork, cabbage, collards, turnips, turnip greens, baking powder, salt, and pepper. All were believed to be of excellent quality for their kind. However, there was no nutritional education of the men to guide them to the best possible use of the foods offered. Six of the eleven men developed symptoms which several experienced observers recognized as those of pellagra. None of the controls showed any of these pellagra symptoms. The earliest skin symptoms appeared at the end of the fifth month; the earliest exaggerated kneejerk in the sixth month. Subjective symptoms such as headache, weakness, and abdominal discomfort were reported by the end of the second month. Obviously the circumstances were quite suggestive to the subjects, but there is no good reason to doubt that the diet gave them pellagra.

VITAMIN C

As is characteristic of the twentieth-century science of nutrition with its many sided and rapid growth and its important human implications, the story of vitamin C is no longer confined to scurvy and the means of its prevention, important as this has been in man's conquest of his world.

The prevention of scurvy is only a part of the comprehensive function of vitamin C in our bodies; and when scurvy shall have become obsolete, the question at what level to consume vitamin C may still be a live problem. The Western World's medical literature of four centuries or so ago showed scurvy then to have been very prevalent during the winters in northern Europe. In fact so

[8] Sweetpotato is now preferably written as a single word to mark it as a misnomer in the sense that it is not botanically a close relative of the ordinary potato.

common was it as to lead to the serious suggestion that all other diseases might be regarded as outgrowths of scurvy. It was also a terrible scourge of the sailors who went on long voyages of exploration in the times of Columbus and of the Elizabethans. But these adventurers did more than they knew for the freedom of their fellow men from the great burden which scurvy had been. For they brought the potato from the New World to the Old, and as potato culture and the year-round use of potatoes as a staple food grew common in Europe, scurvy became relatively rare, except after failure of the potato crop (as in the famine in Ireland in 1843–44), or on long sea voyages, as among the Norwegians with whom the prevention of scurvy was still a live problem when the twentieth century began.

Since early in the nineteenth century it had been known empirically that fruits and their properly preserved juices and fresh vegetables prevent scurvy, and can cure it if taken before the disease is too far advanced. Thus in a sense the practical problem of prevention of scurvy had been solved; but King's identification of vitamin C in 1932 gave the knowledge of its molecular structure from which to plan further studies of the functioning of the substance, and pointed the way for the synthetic production of the vitamin economically and in pure form. Moreover, King's further researches in the field which he had thus opened have clearly shown that our bodies make use of vitamin C in other ways than simply for the prevention of scurvy. And to get the full benefit of the vitamin's action in some of these other processes calls for much larger amounts than are needed to prevent typical or "classical" scurvy.

Outstanding among these further gains is the prevention of infantile scurvy which often remains in the latent or subacute form and so all too often escaped recognition while constituting a serious handicap to the development of the infant. Hess found a high prevalence of such subacute or latent scurvy among infants who did not develop typical scurvy symptoms but were irritable, lacking in stamina, and more or less retarded in growth. The simple feeding of higher levels of vitamin C (usually but not necessarily in the

form of orange juice) results in better growth, higher stamina, and greatly improved general health and disposition. Thus vitamin C is today bringing about nutritional improvements in many lives not only by prevention of scurvy but also in its functioning at levels above those at which there is a scurvy problem.

King and others have also shown other important benefits requiring still higher levels of vitamin C, as will be explained further in later chapters.

THE GENERAL STATUS OF THE VITAMIN CONCEPT BY 1920

Undoubtedly the facing of wartime food problems from 1914 to 1918 accentuated the awakening of nutrition-consciousness. Human experiences of deficiency of one or another of the three vitamins then known had come near enough to a sufficient number of physicians to establish the concept that there are, truly and literally, deficiency diseases; and that henceforth the diagnosis and treatment of disease must deal not solely with the *materies morbi*—the injurious thing or things—but should equally take account of the fact that disease may result from a lack of sufficient amount of some essential nutrient factor or factors.

It was noteworthy that by 1920—the date of Hess' book, *Scurvy Past and Present*—vitamins were already playing an important part (some of it even quantitative) in the science of nutrition although at that time none of the vitamins had been chemically identified in the strict sense of the establishment of its molecular constitution. Even at that time the newer knowledge of nutrition had doubtless saved innumerable lives and improved an even larger number. And much more efficient service was still to come with the increase of scientific knowledge, and of the sense of responsibility for public health.

NUTRITION IN SOCIAL SERVICE TO 1920

Bailey B. Burritt, long the general director of the New York Association for Improving the Condition of the Poor (now the Community Service Society), early grasped, in a highly extraor-

dinary degree, the significance of nutrition for human well-being. From the Milbank gift to that Association for research in social work, a modest grant was made for investigations in cooperation with Columbia University upon the requirements of human nutrition and the adequacy of typical American family dietaries in New York city and other areas. Criteria of adequacy were advanced from the time-honored protein and energy factors to include also calcium, phosphorus, and iron. Lucy H. Gillett became first the laboratory research worker in this investigation, and then the director of the Association's Nutrition Bureau through which the results of the scientific work upon nutritional needs were put directly into its social work. Hazel Munsell and Penelope Burtis Rice successively continued the laboratory work and extended it to include the vitamin values of foods and the adequacy of vitamin factors of typical New York city family dietaries. The influence of this work spread rapidly and widely in a world which was becoming nutrition-conscious under the impact of the food supply problems of a world war and its aftermath of economic depression.

An encouraging fact, found in the course of putting the growing knowledge of nutritional needs into public service through community social work, was that even a few educational visits by the social-worker dietitian definitely improved the food economics and nutritional well-being of the typical low-income American family, and that the improvement continued (at least for some years and probably permanently) after the teaching visits had ceased.

Thus though food habits are traditionally persistent, yet typical families are willing to be taught, and under competent teaching, they do make permanent improvements in the wise use of the money that they can spend for food.

After the close of the First World War it was said in the Columbia University Quarterly (under the caption of "Permanent Gains from the Food Conservation Movement") and reprinted in a Cornell bulletin, that the changes in food habits, which the food-saving campaign had sought to teach, were directly beneficial to the individual American consumer and also to the economic develop-

ment of our national agriculture. We had been asked to "save" wheat, meat, sugar, and fat for our armies and Allies overseas and to eat more of fruits, vegetables, and milk which are too bulky, watery, and perishable to be well suited for overseas shipment, but of which a larger consumption would advance the nutritional well-being of the typical American family. Now, at the middle of the century, this advice is still good. Three decades of further growth of nutritional knowledge show us that the principles on which it was based are even more far-reaching than we could then fully realize. We may refer to them again after reviewing the advances of the intervening years.

CHAPTER V

Advances during 1921–1930 and the Concept of Nutritional Improvement

IN THE DECADE of the 1920s three "new" vitamins were added to the list of our known nutritionally essential substances; and research was also active in the fields of the previously known nutrients and natural foods. In the interest of a more effective coordination with the chapters which precede and follow, we here vary the sequence from that of the preceding chapters and take up the vitamins first.

VITAMIN A AND ITS PRECURSORS

Moore showed that the carotenes, which occur in green and most yellow vegetables, are precursors which the animal body transforms into vitamin A. The vitamin A value or potency of a food is thus due sometimes to vitamin A itself, sometimes to carotenes (provitamin A), and sometimes to both. Quinn, Burtis, and Milner demonstrated the relationship of greenness to vitamin A value in other parts of plants as well as in the leaves. They found green beans and green peppers to be of fairly high vitamin A value. Kramer, Boehm, and Williams found that the outer green leaves may have thirty times the vitamin A value of the white inner leaves of the same head of lettuce. Dye and her co-workers similarly found higher vitamin A value in green than in white parts of asparagus.

Sherman and Kramer showed that, both in early and in middle life, the body has a large capacity to store vitamin A from any surplus that the food may furnish. Independently at the University of Wisconsin and at Columbia it was found that much the largest part of the bodily store of vitamin A is carried in the liver. The concentration of this vitamin in both liver and lung tissue varies with

the vitamin A value of the food. That the level of intake of vitamin A influences the vitamin A content of lung tissue is of special interest in view of the reports that vitamin A increases the body's resistance to respiratory disease. Among comparable animals coming from the same previous diet, age was found to have an important influence upon bodily store as judged from the survival period when the animals were transferred to a diet otherwise good but devoid of vitamin A.

In another series of experiments, made by F. L. MacLeod in 1925, animals of identical genetic and nutritional backgrounds were fed from the end of infancy until natural death upon one or the other of two diets alike and good in other respects but one was of liberal, and the other of low, vitamin A value. The group with a liberal intake of vitamin A or its precursors made normal life records in all respects and left an abundance of vigorous offspring. The parallel animals on food poor in vitamin A (though not entirely devoid of it) lived only about half as long and left no descendants, although most of them maintained every appearance of good health throughout growth and into early adulthood. Evidently, with a good start up to the end of infancy, a deceptively good appearance may then be maintained for a surprisingly long time while the shortage of vitamin A is undermining the vitality and reducing the life span. Something like this doubtless happened more often in human experience before the discovery of vitamin A and of its significance to health and longevity.

It has also been found that along with the failure to reproduce successfully there was a tendency in early adult life to increased susceptibility to infection and particularly to breakdown with lung disease at an age about corresponding with that at which pulmonary tuberculosis shows its well-known high incidence among young people. The bacillus involved is different; but the parallelism of increased incidence of lung infection at this stage of the life cycle appears very significant, especially in view of the fact, found in Boynton's experiments mentioned above, that the vitamin A content of lung tissue varied with that of the food. The conclusion

drawn from these experiments of Dr. F. L. MacLeod in 1925 is still valid, that vitamin A is an even more important factor in nutrition than was previously appreciated, for it must be supplied in liberal proportion not only during growth but in the food of the adult as well, if good nutritional status with a high degree of health and vigor are to be maintained. To a very important degree the body may be insured against the hazard of fluctuations in the vitamin A value of the food, in its absorption from the digestive tract, or in its rate of consumption in the tissues, by such liberality of feeding as shall keep the individual well stocked with vitamin A at all times.

Very instructive were the experiments of Dr. Margaret Cammack (Smith) who fed different levels of vitamin A for different lengths of time and judged the relative bodily storage by then determining how long the animals thus prepared could survive on diet good in other respects but lacking vitamin A value. Thus studied, the bodily store of vitamin A was found to be quickly and largely increased by the addition of extra vitamin A to an already good diet. However, the body only gradually completes the process of acquiring the maximum quantity which it is capable of storing. In the experiments, both when the level of intake of vitamin A was moderate and when it was very liberal, the animals continued to increase their bodily store at least up to full adulthood (six-months-old rats). In experiments comparing the effects of different levels of intake, however, it was found easily possible for a two-months-old rat to acquire from a diet rich in vitamin A an apparent reserve as great as that in a six-months-old animal of the same heredity but of less fortunate dietary history. Later these findings were confirmed and extended using different methods of direct determination of the amounts of vitamin A stored in the experimental rats.

During the decade here under review, several investigators found further evidence for the view previously advocated by McCollum that unrecognized shortages of vitamin A have handicapped the health and diminished the efficiency and resistance of a large proportion of the people hitherto. This view has been confirmed and extended by subsequent studies both of food supplies or family dietaries and of the nutritional status of samples of the populations

of several regions. While not all details are in complete agreement, there is a fair consensus in support of the general view of the importance of more attention to the vitamin A values of dietaries and this advance of nutritional knowledge is reflected in the increased consumption of green and yellow vegetables and of margarines fortified with vitamin A.

Almost simultaneously with the work just cited, Batchelder showed that stepwise gradations of the vitamin A value of the diet are reflected in corresponding gradations of health, vitality, and individual and family life histories. Here again the first findings have since been confirmed and extended by subsequent experiments in larger numbers.

In the summer of 1929 Wolbach, Howe, and Church reported to the International Congress of Physiology that: "The specific effect of the absence of fat-soluble vitamin A in albino rats, guineapigs, and humans is found in epithelial tissues. This effect is the substitution of stratified keratinizing epithelium for normal epithelium in various parts of the respiratory tract, alimentary tract, eyes and paraocular glands, and the genito-urinary tract."

Throughout the latter part of the decade of the 1920s, there was much study and discussion of the extent to which the level of vitamin A intake influences susceptibility or resistance to infection. Partly because the pathologists tend to use these terms in a more technical and restricted sense than our ordinary usage, the literature on this subject is confusing. Perhaps so medical a question lies outside the proper scope of this book in any case. Suffice it to say that while vitamin A very definitely should *not* be called *the* anti-infective vitamin, there is evidence that both this vitamin and some of the others may influence the frequency, or severity, or duration, of some infections.

MULTIPLE NATURE OF VITAMIN B: PREMONITIONS OF RIBOFLAVIN

Mitchell, in a careful review, and Emmett and Luros, both in an independent critique and by excellent direct experiments, attacked the problem of the multiple nature of vitamin B. A source of con-

fusion in the early literature of this problem was the tendency to assume that if two substances were involved one should be antineuritic and the other growth-promoting. Before long, however, it became clear that vitamin B_1 (a relatively heat-labile factor) is both antineuritic and growth-promoting while the relatively heat-stable vitamin B_2 is also growth-promoting, as well as essential to health at all ages. Many other workers independently contributed to the establishment of the multiple nature of vitamin B, or, in terms of today, to the differentiation of thiamine and riboflavin.

Discussion of the differentiated functions of thiamine and riboflavin as factors in the relations of nutrition to health will find its chronological place in the next chapter.

VITAMIN C (ASCORBIC ACID)

Throughout the 1920s, although vitamin C had not yet been chemically identified, methods of measuring relative amounts by virtue of their action (as is done with enzymes, toxins, and vaccines) were being devised. And by the use of these methods much quantitative research was carried out upon such problems as the relative richness of different foods in vitamin C, how well they hold their vitamin C values under various conditions of storage and cooking, and the relative amounts of vitamin C required in nutrition under different conditions.

Thus even before the isolation and chemical identification of the substance much was being learned about it, and the knowledge was being put into service to insure dietaries of high antiscorbutic value with resultant building of health to higher levels.

RICKETS AND THE VITAMINS D

Rickets may be regarded (and its discussion may be approached) in either or both of two ways: as a defect or an undue delay in the mineralization of the bones, and as the disease resulting from deficiency of vitamin D. Strictly speaking, the latter term should be vitamins D, for we now know that there is *more than one antirachitic substance.*

Either (*a*) the mineral content of the food, or (*b*) the combined amount of vitamin D received by mouth and formed in the skin, or (*c*) concomitant shortages of both the mineral and vitamin factors, may turn the scale between the occurrence and the avoidance of rickets.

Moreover rickets may occur in all degrees of severity from those producing marked distortion of the skeleton to those so slight as to be detected only by physicians who specialize in its diagnosis.

Severe rickets—a condition visible to the unaided eye of the layman in the short and distorted skeletons of a large proportion of the poor—was within living memory "the most prevalent disease of the temperate zone" and now has been almost eradicated from progressive communities under the guidance of the new knowledge of nutrition.

During the decade here under review, McCollum and his coworkers definitely differentiated vitamin D from vitamin A, while Hess and Steenbock independently and simultaneously effected the formation of vitamin D by ultraviolet irradiation of foods or other materials containing such vitamin D precursors as certain cholesterols and related substances.

And here again we find that the twentieth century science of nutrition can function not only preventively and correctively but constructively as well.

When the intakes of calcium and phosphorus are liberal so that the needs of the growth and development of both soft tissues and bone are provided for, liberality of vitamin D promotes linear growth, i.e., increase in the length of the skeleton, and especially of the legs.

The superior height and erectness of carriage which in some countries has hitherto been considered "a characteristic of the upper class" depends chiefly on an individual's having long straight legs and is now being largely conferred upon the children of all economic conditions through the discovery of vitamin D and the widespread use of fish-liver oils. (This is quite as important a service of chemistry to democracy as was Dr. Slosson's favorite illustration,

that through the cheap synthesis of the dyestuff "every working-girl can now wear Royal Purple.")

Like many other of the constructive developments of the newer knowledge of nutrition, the favorable influence of liberal intakes of both calcium and vitamin D upon growth, was first shown by experimentation with laboratory animals having a short natural life cycle and then confirmed and extended by clinical experience.

For excellent summaries to about the end of this decade see Hess and Blunt and Cowan in the Bibliography appended to this book.

Osteomalacia was especially studied by Maxwell who found that this disease of the bones which was sometimes considered as a sort of "rickets in adults" is like low-calcium rickets in that it may be prevented or cured (if not too advanced) by the use of a diet of liberal calcium content and by treatment with either codliver oil or sunlight. Use of this knowledge has greatly improved the physique and life history of a large proportion of the population in several regions.

VITAMIN E: TOCOPHEROLS

Evans discovered the existence of some previously unknown factor, essential for reproduction. He called this "factor x"; but usage determined that it be known as vitamin E, with the alternative of the coined term *tocopherol(s)*. In the absence of this substance females temporarily lose the power to bring embryos to full development. Males on a similarly deficient diet suffer complete and permanent degeneration of the seminiferous epithelial cells. Thus this substance is clearly essential; but whether in actual human experience there is any significant chance of its becoming a "limiting factor" is still an open question.

SOME INTERRELATIONS OF PROTEINS, MINERAL ELEMENTS, AND VITAMINS IN NUTRITION

So far in this book it has seemed helpful, to the gaining of a good grasp of the significance of the growth of our science, to make each chapter a chronicle of the developments of a decade. Naturally,

however, it is not to be supposed that research and publication and the development of new viewpoints have followed any such smooth sequence of time cycles, whether of ten years or any other arbitrarily chosen length.

Thus we may well recognize a period of a dozen or more years beginning, say, about 1917, in which the newer knowledge of nutrition was being developed as a quantitative science, with rather radical reform of the previous concepts of dietary adequacy and "balance" and with a great advance in the effectiveness of the concept of nutritional improvement. Experiments both with laboratory animals and with human subjects have contributed to this advance, the findings of each adding significance to those of the other.

Osborne and Mendel, and McCollum and Simmonds, showed how the then recent discoveries, while making nutritional problems more complex, yet helped the situation by demonstrating clearly how significant is the light brought by the newer factors: the differences among proteins, and the importance of the mineral elements and vitamins.

McCollum also emphasized the fact that adequate diets can not be expected from mixtures of seeds alone; for the food-seeds show a general similarity of nutritional characteristics, all of them being too poor in vitamin A value and calcium content, and most of them needing protein or amino acid supplementation if a diet of optimal nutritive value is sought. They considered (and it is doubtless still true) that large numbers of people, even in the United States with its abundant food supply, live on diets composed too largely of products of seeds (together with meats, sweets, and fats) and not sufficiently supplemented or balanced with milk and green vegetables for best results.

Among the problems left to the 1920s by the First World War and its aftermath of economic crisis and depression were: Are other grains nutritionally equivalent to wheat? and, To what extent do those food supplies which consist mainly of grain products need to be supplemented by milk, or milk and other protective foods?

In 1921, McCollum, Simmonds, and Parsons published in the

Journal of Biological Chemistry a group of papers describing experiments designed to test the supplementary relationships among the proteins of different foods, and featuring the use of other criteria as well as growth in their judgment of the relative merits of the various food mixtures studied. We shall have occasion to recur later in this chapter to their use of the concept of optimal diet or nutritional status.

Steenbock, Kent, and Gross had emphasized the urgency of the need for mineral supplementation in building adequate diets around barley.

Hart, Steenbock, Elvehjem, and Waddell published in 1925 the first of their series of papers on iron in nutrition. In later papers they included the account of their discovery that copper is essential to the utilization of iron in the building of hemoglobin in the body, though the copper does not become a constituent of the hemoglobin.

Copper is therefore counted among the nutritionally essential mineral elements, but it is believed that any diet containing a good proportion of natural food will be abundantly supplied with copper without special planning.

Unlike copper, *iron does* become a part of the hemoglobin itself. Yet much research has now shown that the anemias are much more than iron deficiencies. Even those in which the administration of iron is therapeutically helpful are not necessarily caused by shortages of iron in the food.

Shortages of iodine would be frequent in several regions if our dependence for this element rested upon food alone. This may be avoided by the use of iodized salt.

Calcium is therefore the mineral element most likely to be a limiting factor in the usual dietaries of American, European, and probably most other peoples.

In the light of the above findings, and of others mentioned in the preceding chapter, several investigators made numerous studies —by means of quantitative chemical determinations of the balance of bodily intake and output—which showed that liberal provision

of dietary calcium is even more important than had previously been appreciated as an outstanding factor in giving all children a fair chance for a good start and also for vigorous adult life. This importance of calcium to bodily development and to a good life history has been confirmed by much additional research in the intervening quarter century (summarized by Sherman, 1947).

THE CONCEPT OF OPTIMAL NUTRITION

Obviously the term *optimal* (adjective) or *optimum* (noun) means *the best*. The word *adequate* has no such clear-cut and indubitable meaning. Probably, to most of us, to say that a dietary or a bodily condition of nutrition is adequate means about the same as to say that it is *passable*.

In papers reporting the results of testing nutritive values of diets by means of feeding experiments, one may read that a given food-mixture supported not only growth but also normal reproduction and rearing of the offspring. Performance in these latter functions is subject to larger individual variations than is growth, and unless experiments are made in large numbers we do not know *how* satisfactory, in a quantitatively measured sense, was the positive finding. If the experimental animal shows a passable performance in reproduction (and rearing of offspring) this is usually taken as evidence that the dietary is adequate from the viewpoint of this criterion. It is straining the language to try to insist that "adequate" shall mean adequate to the realization of the very highest degree of performance for which there is inherent possibility. That would be trying to make *adequate* mean the same as *optimal* and thus to blot out a useful distinction which McCollum has frequently and consistently made in statements to the effect that there is or may be an important difference between the adequate and the optimal in nutrition.

Thus McCollum, Simmonds, and Parsons in testing and reporting, in 1921, upon the relative merits of a series of diets, could make a useful discrimination by reporting that in a given case the level of performance, while passable, was not such that the diet could be

considered optimal, that is, it was a merely adequate and not an optimal diet. (To uphold good scientific practice we should use the word *optimal* only for the *very best* that we can conceive, and not countenance the careless habit of speaking of a diet as optimal when all we know is that it is something better than merely passable.)

In one of the series of papers just mentioned, McCollum, Simmonds, and Parsons write of a rat family, which reared a few, but only a few, offspring, that with optimal nutrition the numbers of offspring reared should have been two or three times as large as in these cases they actually were. And they report on two "lots"—one with a reproduction record distinctly lower than that of the other whose diet was identical except for the addition of 3 percent of butterfat. Of another experimental group a significant part of the record was that all these animals showed unduly early signs of old age; while of still another the final finding was that further studies would be needed to determine what modifications of this diet would result in greater fertility and higher vitality in the young. At another point they explicitly state that since in many cases growth data revealed no essential differences, their bases for judgment in this series of comparison of diets were relative fertility and infant mortality. They also state that observations on the growth curves of a group of animals to maturity do not enable one to arrive at safe deductions concerning the quality of an experimental diet, such as can be arrived at through studies of individual life histories and family histories through successive generations. They explicitly postulate that, in comparing parallel groups on different diets, the finding of higher fertility in one group may be taken to indicate that these individuals "were in a distinctly better state of well-being" than those on the other diet. As part of their record of one such comparison they wrote that the animals on one diet were as old looking at 14 months as were those on the other diet at ages from 18 to 20 months. Another diet was found suboptimal through the fact that the rats subsisting on it "were very old looking at 15 months of age." The rats on a different suboptimal diet were re-

ported old looking at 16 months. On still a different diet the rats "looked very old at about 12 months." On a diet different from any of the above, growth was excellent and fertility high but infant mortality was very high and the original rats looked very old at ages ranging from about 16 to 18 months.

Still a different diet showed itself suboptimal by high infant mortality in families receiving it, notwithstanding the fact that it had supported unusually good growth and fertility in the original experimental animals. Another diet supported good growth, but the animals receiving it were rough-coated, old-looking, and irritable, at 12 months of age. In their judgments as to whether a diet is optimal or nearly so, they gave considerable weight to the age at which the rats subsisting upon it began to show the coat changes characteristic of incipient retrogression toward senility which they took as an index to the transition from the youthful to the senile condition. (The more nearly optimal the diet, the better the conservation of the characteristics of youth.) They stated that they had given a great deal of attention to the problem of demonstrating the effects of relatively slight defects in the diet on the general health of the rat, and on its capacity to reproduce and rear young, and to remain vigorous to an advanced age. They consider that the type of animal feeding experiments in which the performance of the production and nursing of young are included among the laboratory observations, brings to light the "twilight zone" of nutritional status in which vitality is below the optimum though no gross deficiency has become manifest. Probably there are many more people existing in this twilight zone than there are among those who are grossly malnourished in any specifically demonstrable respect. Interest and success of the experimental rats in the rearing of their young is thought to be an important index to such shades of excellence in the diet as are of special value in seeking the optimal nutrition of the human family.

McCollum, Simmonds, and Parsons defined the optimum in diet as that which best promotes growth, supports highest fertility and greatest success in rearing young, preserves for as long a period as

possible the characteristics of youth, and extends the life span to its limit. To realize such a diet in practice—in this country where people are accustomed to take so much of their nourishment in the form of breadstuffs, potatoes, meats, and sweets—calls for real thought and much care in the selection of the remaining foods. They found milk the food deserving of most emphasis in this connection.

McCollum and Simmonds emphasize the view that advances in the twentieth century in our knowledge of nutrition hold greater value for preventive medicine through the raising of vitality with all that this implies, than through the combat of the frank deficiency diseases. This means that in the aggregate, by far the most important effect of faulty nutrition in man is the gradual undermining of health and vitality which results from errors that are unperceived but more or less constant and do not at any time produce the dramatic effects of the gross deficiencies. Of these unrecognized deleterious influences, they held that the consumption of an improperly constituted diet is one of the most important. For, it is, they write, one of the causes of inferiority in physical development, instability of the nervous system, lack of recuperative power and endurance with consequent cumulative fatigue, and lack of resistance to infectious diseases, such as tuberculosis.

Reformation of food habit under the guidance of today's knowledge of nutrition can, they held, largely avoid these insidious ills, and at the same time contribute to longer life and to conservation of the characteristics of youth.

The texts of the third and fourth editions of McCollum and Simmonds', *The Newer Knowledge of Nutrition* (published in 1925 and 1929) end with about a page of parting advice entitled "The Most Satisfactory Type of Diet." Here these authors state that "the first and most important principle is the extension of the use of dairy products." Both editions recommend the consumption of about a quart of milk per person per day, and state that the pastoral peoples have owed their physical superiority to their high level of milk consumption. Their second principle is that "there are dietary

properties in the leafy vegetables which are unique among foods of vegetable origin." The liberal consumption of these leafy vegetables is advised both for the substances which they bring into human nutrition and for their aid in the maintenance of good intestinal hygiene. And finally a "third principle of great importance" in human nutrition is the inclusion of sufficient antiscorbutic food in the diet. These authors add in both editions a recommendation of codliver oil and sunshine to safeguard the skeletal development of infants and children; and in the 1929 edition a closing paragraph is given to the special importance of the right nutrition of expectant and nursing mothers.

Simultaneously with the work of McCollum, Simmonds, and Parsons cited above, feeding experiments with simple mixtures of natural foods were also in progress in the laboratory of the department of chemistry of Columbia University. Some exploratory tests indicated that with the rat as the experimental animal a mixture of one sixth dried whole milk with five sixths ground whole wheat (plus table salt and pure water) constituted an adequate diet, but that the rats thrived better when the proportion of milk powder in the food mixture was increased to constitute one third of the wheat-and-milk mixture. This appeared therefore to be one of the situations in which, as McCollum had pointed out, there may be important differences between the merely adequate and the optimal in nutrition. Moreover, without assuming or believing that the better result is necessarily optimal, the improvement of an already adequate diet and of a passably normal level of health and performance of life functions may be importantly significant in itself if established with sufficient convincingness. Different aspects of the life histories of the experimental animals were therefore studied quantitatively in side-by-side comparisons of strictly parallel individuals or families on the diets differing only in the relative proportions of the natural foods of which they are composed. For the convenience of the reader these are designated as Diets A and B, respectively, and as an aid to memory it may be pointed out here that Diet A is *adequate* (in the ordinarily accepted sense of the

term), while Diet B is *better*, without necessarily being the very best that could be worked out.

Sherman and Muhlfeld compared the numbers and weights of young borne and reared by parallel series of 10 mothers on each diet.

In addition to the complete reproduction records of these strictly parallel series of 10 mothers each, the comparison of the diets in this respect was also extended to all the litters born in this laboratory on these two diets during the year 1920. There were 167 litters born on Diet A and 402 litters born on Diet B. With such numbers included in the comparison there could be no doubt of the significance of the observations that the larger proportion of milk in the family diet resulted in the following evidences of nutritional improvement in the life histories of the mothers and young: (1) Increase in the number of young produced. (2) Increase in the percentage (and therefore also in the number) of young successfully suckled. (3) Better maintenance of the body weight by the mother while suckling the young. (4) Higher average weight of young at a standard weaning age of four weeks. (5) More economical utilization of the calories of food consumed, as well as of the body material of the mother, in the rearing of the young to weaning age.

At the same time with the work just described, Sherman and Crocker studied the efficiency of growth, from the 28th to the 56th day of their ages, in young rats of families on the Diets A and B described above and also Diets C and D containing respectively one half and two thirds of dry whole milk in the wheat-and-milk mixture. From 129 to 164 individual animals (in from 30 to 39 separate lots) were included in this study of which the results, given in Table 5, are accompanied by their respective probable errors. Upon comparison of these, it is clear that there was a certain and highly significant gain in efficiency of growth on Diet B over that on Diet A, while as between that on Diet B and either Diet C or D the difference was so small as to be of doubtful significance.

Here again it is clear that there was a nutritional improvement on Diet B over the already normal status supported by Diet A. The differences of life histories in otherwise strictly parallel experimental

TABLE 5

EFFICIENCY OF GROWTH ON DIFFERENT DIETS

Diet	*Number of lots*	*Number of rats*	*Average gain in grams per 1000 Calories of food eaten*
A	32	163	54 ± 0.6 [a]
B	39	164	73 ± 0.8
C	34	164	74 ± 1.1
D	30	129	76 ± 1.1

[a] The precision measure following the ± sign, here and elsewhere in this book, is the classical Probable Error of the mean.

animals on Diets A and B were therefore studied farther by Sherman and Campbell whose chief findings are summarized numerically in Tables 6 and 7. It will be seen that Diet B was an improvement upon the already adequate Diet A and that the nutritional improvement induced by the better diet showed itself objectively at all stages of the life history.

The significance of these nutritional improvements will appear more fully in later chapters. For this chapter, it suffices to summarize this part of the Columbia work as follows:

Starting with a diet which was shown to be adequate in that it supported growth, reproduction, and successful suckling of the young for generation after generation,[1] it was found that an increase in the proportion of milk in this already adequate diet resulted in the following evidences of improved nutrition.

1. More rapid growth, particularly as measured by the gain in weight during the period following weaning.

2. More efficient growth during the same period as shown by greater gain in weight per 1000 Calories of food consumed.

3. Somewhat larger average size at all ages.

4. Earlier maturity as shown by age of female at birth of her first young.

[1] When the experiments summarized in Tables 6 and 7 were begun the adequacy of Diet A had been tested through four generations. Later, some of the rat families were continued on Diet A, and when this is written in November, 1949 they are still thriving in the 70th generation upon Diet A alone.

of vitamin A by a period of dieting on vitamin-A deficient food, they still had higher resistance to infection by virtue of the better diet received in infancy.

The evidence summarized in the foregoing pages including Tables 6 and 7 is believed to establish conclusively the principle of nutritional improvability.

There is also excellent direct evidence, particularly in the work of Mann which we describe elsewhere, that this principle applies to human beings. Four of the human studies belong to the decade reviewed in this chapter.

AUDEN'S WORK WITH EXTRA MILK FOR CHILDREN

Auden's experiment was to determine whether the feeding of a supplementary meal of milk would have measurable effect either upon undernourished or poorly nourished children and also upon supposedly adequately nourished children, in both cases with normal or average children of the same age and sex as controls. Among the poorly nourished children, the first and most noticeable result of the extra ration was reported as "an improvement in bodily and mental vigor," with an increase of about one fifth in the hemoglobin content of the blood, and a greater gain of body weight than was shown by the controls. When extra milk was likewise given to a group of the supposedly normal or average children, they also responded in weight gains and hemoglobin. In the month after the extra milk had been stopped, both groups which had received it showed some recession in hemoglobin, in rate of gain of body weight, and in "brightness and spirits."

MC COLLUM'S EXPERIMENT IN A NEGRO ORPHANAGE [2]

McCollum described his subjects as a group of children who because of poverty, or of a lack of knowledge on the part of those in charge, were being fed a diet which he suspected to be inadequate though it was not so recognized. In a well-constructed orphanage

[2] Abstracted from pages 541–51 of *The Newer Knowledge of Nutrition*, 3d edition.

there lived somewhat over 200 Africo-American children ranging in age from infancy to 12 years. The attitude of those in charge was good, but financial resources were meager. Of the children, 84, between 4 and 10 years of age and free from known syphilis, were taken for the experiment. Half of these children were continued on the regular orphanage dietary while the other half were given, in addition to the regular diet, 1 quart of whole milk per child per day, for from 15 to 21 months. This resulted in much better gains in weight, while at the same time the children receiving the milk ceased to be apathetic and developed much more desire for activity. McCollum considered that the results constituted "a most satisfactory demonstration of the validity of the view that a dietary selected from cereals, tubers, fleshy roots, and meat does not prove satisfactory for the physical development of young children"; and that it "shows further that milk is as effective a supplementary food for such a type of diet as has been repeatedly shown to be the case with experimental animals."

MANN'S EXPERIMENT WITH ENGLISH BOYS [8]

Dr. H. C. Corry Mann experimented under the auspices of the British Medical Research Council to test the effects of variations of diet upon the growth of boys in height and weight. His subjects were doubtless in better nutritional status at the start than were those of Auden or of McCollum, described above. His project was therefore more ambitious and advanced from the viewpoint of our present study, in that it sought to improve upon a higher initial nutritional status. Dr. Mann's boys were all in a good state of health and were receiving a dietary "medically adjudged to be adequate." Their accustomed diet was also characterized as having been "planned with every regard for the welfare of those who were to receive it."

This accustomed dietary was continued as the regular diet of the control groups and as the basal diet of all experimental groups receiving supplementary additions.

[8] See Bibliography under Mann, H. C. C.

The experiment was made under conditions exceptionally favorable to full and accurate control, in a boarding-school village containing from 500 to 600 boys at a time, lodged in dormitory houses in groups of 30 or more, each group having its own table in a central dining hall, where the basal and control diet was prepared and served in exactly the same manner for all. Moreover, in the experimental groups every boy sitting at a given table, received the same supplementation, so that there was practically no danger of any boy receiving anything different from what was planned for his group.

While the boys of this school population ranged from seven to eleven years of age, they were so arranged that the groups to be compared with each other were of the same composition as to age, and practically the same also as to initial average height and weight.

The experiment was started in 1922 with 90 boys divided evenly among three cottages. In House No. 1, each boy received always the basal diet of the village, living under close observation with recording of general health, gain in weight, and increase in height. In House No. 2, each boy received daily one pint of fresh milk (388 Calories) in addition to the basal diet. These two groups (the first having only the basal diet, the second having also the ration of extra milk) were maintained throughout the experiment, the numbers being increased as well-matched pairs of boys became available; and whenever a vacancy occurred it was immediately filled with a boy of similar age and weight. Data of only such boys as had been maintained for a full year in comparison with their respective controls were used in computing the average results. In many cases the comparisons were continued through a second, and in some cases through a third, year. In other Houses the additions to the basal ration were: No. 3, sugar (350 Calories); No. 4, butter (387 Calories); Nos. 5 and 6, watercress (½ to ¾ oz.); No. 7, casein (equal in amount to the protein of the added milk of No. 2); No. 8, vegetable margarine (379 Calories).

None of the other additions to the diet gave results at all closely approaching those which resulted from the extra milk. The boys who had the extra milk not only gained more in height, weight, and

general fitness but also showed better condition of the skin and were much less troubled with chilblains.

The 41 boys who received the extra pint of milk daily for at least a year made an average annual gain of 2.63 inches in height and 6.98 pounds a year in weight. The corresponding average figures for the boys who constituted the direct controls were 1.84 inches and 3.85 pounds. Thus the extra milk increased the gain in height by 43 percent, and the gain in weight by 81 percent.

Undoubtedly the increased gain in both height and weight at ages of from seven to eleven years signifies superior nutritional status in the boys who received the extra milk. Moreover, the increased gain in physique and positive health will usually mean increased earning power as well. In Chapter XI we shall recur to Dr. Mann's outstanding experiment in our consideration of the question, what more than the biological and economic advantages may be expected from the nutritional improvement of life.

LANARKSHIRE EXPERIMENT OF LEIGHTON AND MC KINLAY

Leighton and McKinlay reported the Lanarkshire experiment in which, of nearly 20,000 school children, one half received an extra ration of ¾ pint of milk every school day for four months, while the other half of the children continued on their usual home diet. According to the officially published conclusion: "The results . . . demonstrate that the addition of milk to the diet of children has a striking effect in improving physique and general health, and increasing mental alertness." And also that "the general introduction of milk feeding in schools, by improving . . . physical and mental well-being, would have a powerful influence in improving the quality of the Scottish race."

In this investigation the children were from five to twelve years of age. They were weighed to within an ounce and their heights measured to one eighth of an inch. Both the children getting the extra milk ration and their controls were considered representative of the general child population of Scotland.

The children receiving the extra milk grew better both in height and weight. There was no obvious or constant difference in this respect between the boys and girls, and there was considered to be little evidence of any definite relation between the age of the child and the amount of its improvement. "The results do not support the belief that the younger derived more benefit than the older children. As manifested merely by growth in weight and height, the increase found in younger children through the addition of milk to the usual diet is certainly not greater than . . . that found in older children." Inasmuch as the milk given was an addition to "the usual diet," it may be that the younger children were getting more milk than the older children in their home diets, in which case the older children may have stood in more urgent need (than the younger ones) of the particular nutrients characteristic of milk. Probably in nearly all countries a large proportion of families have learned the importance of milk to the younger but not to the older children.

When the investigators invited the school teachers to report their observations, the replies showed a general and definite opinion on the part of the teachers that the children who had been getting the extra milk for from six to eight weeks or more showed a clear advantage over the controls in an increase in the bloom of their cheeks and the sleekness of their skins, in physical energy, and in that they were more high-spirited. Some teachers said the children getting the extra milk were boisterous and more difficult to control, but that they were more regular in school attendance. "Many teachers," the investigators wrote, "are quite emphatic in stating that mental lassitude gave place to alertness" in the children who received the extra milk.

CHAPTER VI

Nutrition in the Decade of 1931–1940

THE DECADE FROM 1931 TO 1940 brought important advances in knowledge of each of the vitamins outstanding in human nutrition, and also saw significant development in other aspects of the relations of nutrition to health. For the reader's convenience we here take up first some items closely related to those in the latter part of the preceding chapter, and then such aspects of the individual nutrients as bear most directly upon nutritional improvements of life processes.

WORK OF THE "MILK NUTRITION COMMITTEE"

A very significant experiment was published in 1938 by the Milk Nutrition Committee under the title *The Effects of Dietary Supplements of Pasteurized and Raw Milk on the Growth and Health of School Children.*

This experiment began with 8435 children (between the ages of five and fourteen) of whom 6099 remained in the project throughout and took all of the examinations it involved. These children were divided about equally into four groups as follows: (1) children to serve as controls receiving biscuit instead of milk as the school supplement to their home diet; (2) children to receive ⅓ pint of pasteurized milk a day as school supplement to their home diet; (3) children to receive ⅔ pint per day of pasteurized milk, similarly; (4) children to receive ⅔ pint per day of raw milk, similarly. The experiment was continued throughout a full year.

The data of the physical and medical examinations are fully recorded. Besides such examinations, teachers graded each child four times at regular intervals as to whether he belonged to the high, middle, or low category of brightness of mind. This grading, also called the teacher's assessment of the child's intellectual ability,

was made at each of four dates in the experimental year. This permitted a numerical expression of the percentage of children in each group who had moved up (and the percentage, if any, who had moved down). Subtracting the latter from the former yielded a net gain score for the influence of the child's food upon its year's progress in the development of the mind or of intellectual ability.

The investigators concluded, first, that the supplementary feeding of milk produced greater increments in height, weight, and chest circumference than did the biscuit supplement, and that these differences were greater in the groups getting ⅔ pint than in those getting ⅓ pint of extra milk. This was true for both sexes and at all ages studied. And second, they concluded that the supplementary feeding of milk produced a greater improvement in the intellectual ability of the children than was shown by those who received biscuit instead of milk.

No difference appeared between the results obtained with raw milk and those obtained with pasteurized milk. The British child feeding experiments are summarized connectedly in Chapter XI.

VITAMIN A AND ITS PRECURSORS

In September, 1931, the *Journal of the American Medical Association* editorially spoke of vitamin A as acting to make effective the body's "first line of defense" against bacterial invasion.

This is an appropriate analogy so far as it goes; but it does not tell the whole story.

At no time has there been an entirely clear-cut consensus of competent opinion as to how far vitamin A acts anti-infectively.

In 1932, Harris, Innis, and Griffith concluded that the action of vitamin A in preventing keratinization of the mucous membranes was the main part of its anti-infective effect. It was not found to influence general immunity. Nevertheless, Boynton and Bradford found that animals well nourished with vitamin A were more resistant to standardized experimental infections even when the causative agents were injected subcutaneously, thus by-passing the "first line of defense."

A general review and discussion of the influence of nutrition upon resistance to infection is found in an article by Claussen.[1] The importance of the vitamin A reserves of the human infant and child are discussed by Ellison and Moore.[2]

Dr. A. D. Holmes and others found that vitamin A helps to reduce lost time in industry. Jeans and Zentmire found vitamin A deficiency very prevalent among Iowa children, while Jeghers studied its degree and prevalence among adults. Undoubtedly, increased appreciation of vitamin A means much for the enhancement of health.

Dr. F. L. MacLeod and others found that vitamin A value varies with depth of color in sweetpotatoes.

Dr. Jennie Rowntree reported that the taking of mineral oil diminishes the absorption of vitamin A from the alimentary tract.

In 1938, Youmans and Corlette reported specific dermatoses due to vitamin A deficiency.

General agreement upon the mode of expression of vitamin A values in International Units (I.U.) was reached during this decade. A quantitative method based upon single feedings of materials to determine their vitamin A values was also developed to a high degree of accuracy[3] and has greatly facilitated some of the subsequent studies of the relation of this vitamin to the building of the higher health.

THIAMINE (VITAMIN B_1)

Vitamin B_1, after being chemically identified by R. R. Williams, was renamed by him at the request of those having to do with problems of terminology from both chemical and medical points of view. He coined the term *thiamine* which indicates the presence both of sulfur and of an amine group in the molecule.

Thiamine was found to function in the body by helping the transformation of carbohydrate through the lactic- and pyruvic-acid stages. As this is a process very widespread in the body the restora-

[1] *Physiological Reviews*, 14 (1934), 309–50.
[2] *Biochemical Journal*, 31 (1937), 165–71.
[3] See Sherman and Todhunter (1934) in the Bibliography.

tion of its full vigor may bring relief to what in most respects would seem widely separate ills. Williams and Spies gave special attention to this scientific fact lest the helpfulness of thiamine in so many directions should sound as if it were being promoted as a cure-all.

With the differentiation of the B vitamins from each other, thiamine was found to have the most important part in the stimulation and maintenance of appetite, and not merely in the sense that its presence in the food makes the food appetizing. For, when a thiamine-deficient rat which has lost his appetite is fed thiamine *separately* it will then return with appetite to the food which it had refused. In answer to the question whether thiamine may stimulate appetite too far, investigators have reported that it restores appetite to its normal (most desirable) level, and stabilizes it there.

Thiamine is also important to the maintenance or restoration of the normal tone of the digestive tract, and to the normal utilization of the products of digestion after their absorption into the true physiological interior of the body. Particularly, as already mentioned, it is essential to the normal prompt transformation of the lactic and pyruvic acids which, if allowed to accumulate in the blood and tissues because of even slight ("subclinical") shortage of thiamine, may have more or less deleterious effects upon heart action, nerve functioning, general tissue tone, condition of the joints, or in other or several ways.

Thiamine occurs in all parts of the body, but the capacity of the body to store thiamine is relatively small.

This, with the fact emphasized by Williams and Spies that all active tissues need thiamine for the performance of their normal functions, presumably means that there is stronger reason for advocating liberal intakes not only per day but literally each day than in the cases of most other nutrients.

Since thiamine became easily obtainable in pure form (about the middle 30s) research into its functions has been greatly accelerated, appreciation of its importance both in normal nutrition and in therapy has grown, and doubtless it has played a significant (even

when not a separate) part in the general building of health to higher levels.

Several investigators (including Balkin and Maurer; Colby *et al.*; and Poole, Hamil, Cooley, and Macy) studied the effects of different thiamine intakes upon children. Their results as a whole indicate that moderate liberality of thiamine content of food tends, as noted above, to stabilize the appetites and growth rates of children at norms conducive to general well-being.

The investigations of Elsom, of Wilder, and their respective coworkers afford much evidence that in the population of the United States during the patent-flour era from about 1890 to 1940 there was widespread subclinical thiamine deficiency which either went entirely unnoticed or was considered a vague neurasthenia attributable to the "pressure of modern life."

Strauss of the Harvard Medical School, in a paper on the therapeutic use of thiamine published in the American Medical Association's 1939 Symposium on vitamins, held that thiamine deficiency in man involves predominantly the nervous and circulatory systems and was much more prevalent than was realized even by most physicians. This was partly because the onset of thiamine deficiency is generally insidious, and partly because it came about most often through the combination of a relative shortage in food with some unfavorable bodily condition and was more apt to be classified under the latter than as a deficiency disease.

Strauss emphasized the fact that because most patients' diets are only partially and irregularly deficient in thiamine, individuals may continue for months or years in a subclinical condition while getting in their food amounts of thiamine which are insufficient for recovery but which are large enough to prevent the subclinical condition from becoming clinical.

In 1938, Williams and Spies emphasized the view that while frank beriberi is relatively rare in the United States, vague ill-health resulting from borderline shortages of thiamine with or without other nutrient factors may be and probably are much more frequent than is generally appreciated. They wrote that clinicians were only

beginning to realize that the effects of slightly but persistently faulty diet may not be detectable for years. Williams and Spies (1938) held also that thiamine deficiency (usually unrecognized) was of frequent occurrence among children.

In addition to the relations of thiamine to appetite and to the normal motility of the alimentary tract already mentioned, Williams and Spies emphasized the frequent relationship of cardiovascular disorders to shortages of thiamine of even such mild degree as often to fail of recognition.

Weiss and his co-workers in Boston found shortage of thiamine to be a frequent factor in cardio-respiratory diseases; while Wilder's group at the Mayo Clinic considered it as one of the causes of frequent neurasthenias as briefly noted above.

Vorhaus, Williams, and Waterman obtained favorable results from increased intakes of thiamine in cases of various types of polyneuritis as encountered in New York city hospitals.

Strauss and McDonald reported success in the treatment of the neuritis of pregnancy by giving diets rich in thiamine.

It was therefore with a well-justified hope of benefit to a large part of the population from an increase of their thiamine intake, that the National Research Council and American physicians generally came to favor *the enrichment program* as the movement for fortification of flour and bread with thiamine was called. Wilder, who was very influential in this movement, owed his enthusiasm largely to the many observations by himself and his co-workers which they interpreted as showing that much of the all-too-common neurasthenia results from chronic low intakes of thiamine such as should be corrected if all bread were made to carry its share of the thiamine needed in human nutrition. It is reasonable to believe that the thiamine enrichment of breadstuffs has improved the health of a large proportion of the American people. But as there were no comprehensive statistics of the prevalence of subclinical neurasthenia, or of other forms of sub-clinical shortage of thiamine, we cannot expect to have any precise estimate of the influence of increased thiamine intake upon the number of people thus rescued

from nerve and heart troubles, nor of the extent to which the more liberal amount of thiamine obtained through their food supply since 1940 has raised the general health level of the American people.

RIBOFLAVIN (VITAMIN B_2 OR G)

The preceding chapter sketched briefly the differentiation of the original vitamin B into a more heat-labile part (vitamin B_1) and a more heat-stable part (vitamin B_2). We have seen that the former, after its chemical identification, was renamed thiamine. The more heat-stable part was found to include several vitamins, of which the one first clearly identified was given the name riboflavin. It is found widely distributed in the active tissues of both animals and plants, notably in combination with protein and phosphoric acid, forming an enzyme which is active in tissue respiration and hence called a respiratory enzyme (also Warburg's enzyme or Warburg's yellow enzyme).

Riboflavin occurs also in other more or less related combinations. So far as is known the different natural forms of riboflavin are equivalent to each other and to synthetic riboflavin as factors in the nutritive values of foods.

The *Journal of the American Medical Association* characterized riboflavin as "essential to the defence powers of the organism." Pinkerton and Bessey showed that the level of nutritional intake of riboflavin greatly influences the body's ability to resist certain infections. There have been differences of view as to the relation of riboflavin deficiency to some other diseases. It is a factor in positive health, and one may say that whatever may be the case regarding its relation to certain diseases, the relation of riboflavin to health is undoubtedly very important. The food should provide it in abundance if it is to support the highest health and efficiency of which the individual is capable.

While riboflavin is widely distributed in natural foods, some are much richer sources than others. It is interesting that milk, eggs, and green leaf vegetables—essentially the foods which McCollum

had called "protective" because of their calcium and vitamin A values—now turn out to be good sources also of riboflavin.

During the three years from 1938 through 1940, there was rapid growth of knowledge of riboflavin deficiency (*ariboflavinosis*) as a human disease currently rather prevalent in the United States. Sebrell and Butler described it with special reference to inflammation and cracking at the angles of the lips (*cheilosis*). Quickly these observations were extended to other skin symptoms and to related ocular manifestations (the eye being a specialized skin-spot as pointed out by P. L. Day whose animal experimentation threw important light upon the human problem). Of special interest are the papers (listed in the Bibliography) of Sydenstricker; of Kruse, Sydenstricker, Sebrell, and Cleckley; and of Sydenstricker, Sebrell, Cleckley, and Kruse. The last-mentioned paper is probably representative of subclinical shortages of riboflavin, very widespread in our own and other countries. While restriction of food supplies by poverty is one major cause, another was found to be bad dietary habits with inadequate intake of milk, eggs, and green vegetables. Among the cases thus explained were numerous members of a hospital staff who considered themselves well-nourished and who came under observation simply because of cracked lips, "eyestrain," dimness of vision or undue sensitiveness to bright light. These cases were cured by riboflavin and doubtless the conditions could have been prevented by adequate use of foods of liberal riboflavin content,—particularly milk and green vegetables which McCollum had advocated as "protective" against shortages of calcium and vitamin A.

Riboflavin as a factor in the higher health. The gains from supplying liberal amounts of riboflavin in the dietary appear to be steadier growth with better development, higher adult vitality, greater freedom from disease at all ages, and longer life with a larger fraction of it spent in the "prime" between the attainment of full adult capacity and the onset of old age.

Medical opinion as to how prevalent riboflavin deficiency is in the United States varies with diagnostic methods and their inter-

pretation. It seems clear that riboflavin deficiency has had a large share of the responsibility for pellagra as this term has been used by physicians generally; though there is now a tendency to try to make pellagra mean niacin deficiency "by definition."

Obviously the problems of usage of medical terms cannot be solved in these pages; but it seems certain that what was learned in the thirties about riboflavin as a factor in nutrition and food values has already borne good fruit, and will bear much more in the reduction of disease and the building of higher health among the people of our own and several other countries.

PELLAGRA AND NIACIN (NICOTINIC ACID)

The word *pellagra* originated in Italy and it signifies a roughened or rough red skin. Pellagra as a disease is characterized chiefly by (1) the dermatitis which suggested the word and which usually develops in some strikingly symmetrical pattern, (2) disturbance of the nervous system, and (3) sore mouth with more or less disorder of the digestive system. The disease had been known in Southern Europe and associated with poverty since the times of great dearth which followed the Napoleonic wars.

It was first clearly recognized as occurring in the United States in 1907 and 1908. Thereafter the reports of its occurrence increased very rapidly for some years, while also a great many cases doubtless went unreported. The recorded deaths from pellagra annually in the United States ranged for some time between 3,000 and 10,000; and it was estimated that the number of people suffering from pellagra was about 20 times as great as the number of deaths. From 1914 to 1915 and onward the disease was investigated actively from both sanitary and nutritional points of view. Goldberger was outstandingly active in showing that pellagra was nutritionally preventable. Search for the actual (chemically individual) substance which prevents pellagra extended through fully twenty years, being complicated by the fact that typical clinical pellagra, as the term was used and understood, commonly involved more than one nutritional deficiency. But when in 1937 and 1938 it was found that the sub-

stance long known as nicotinic acid (more recently renamed *niacin*) was capable of preventing all the more constant and outstanding aspects of pellagra, it was called the pellagra-preventive substance, and medical usage began to write into the definition of pellagra that it is preventable by niacin (nicotinic acid) or its amide; though some medical writers consciously defined their pellagrins as patients suffering from deficiency of niacin and riboflavin.

The number of such sufferers from malnutrition has since 1937 been very greatly reduced, and it is reasonable to hope that even the subclinical cases can be practically eradicated in the near future.

King has given [4] an excellent concise account of this development and characterized it as an illustration of the rapidity with which the results of animal experimentation may be used for the betterment of human health.

OTHER MEMBERS OF THE B GROUP OF VITAMINS

This book is written from the viewpoint of the improvement of human nutrition. It therefore makes no attempt even to enumerate all the known vitamins nor to account for all the substances that have been postulated and designated by subscript numerals as relatives of vitamin B or as belonging to the B group. Thiamine, riboflavin, and niacin are the only members of this group that need enter this story.

VITAMIN C (ASCORBIC ACID)

We have seen that the existence of a definite (chemically individual) antiscorbutic substance was postulated over a century ago by Budd who predicted that "in a not far distant future" the substance would be chemically identified. This was done by C. G. King and his co-workers in 1932.

Fortunately this substance turned out to be one which is producible by synthesis at moderate cost. This means not only that synthetic material is now available for nutritional fortification of

[4] C. G. King, *Annual Review of Biochemistry* (1939), 383–84.

foods or dietaries when desired, but also that the pure substance can be had in sufficient abundance to facilitate researches upon its behavior as a nutrient.

King and Menten found that liberal doses of vitamin C greatly increased the ability to resist diphtheria toxin.

Crandon, Lund, and Dill studied the case of Dr. Crandon himself when living experimentally without vitamin C for six months and eighteen days. The first signs of scurvy which they were able to observe were hemorrhagic areas around the hair follicles of the legs after five months without vitamin C. During the fourth and fifth months there was some lassitude, but marked fatigueability did not appear until the sixth month. An experimental wound made after three months healed quite normally, but an exactly similar one made after six months without vitamin C showed no healing after ten days. Then one gram of vitamin C was given intravenously each day for ten days in succession, which resulted in complete healing of the wound. Thus the influence of vitamin C upon wound healing was demonstrated most convincingly by a surgeon experimenting on himself. This healthy young man showed apparently little outwardly visible effect except increased fatigueability and decreased wound healing when he had lived for five months with no detectable amount of vitamin C in his food. The plasma vitamin C had disappeared in 42 days; that in the white blood cells only after 122 days. The advantage of liberal vitamin C in the healing of experimental wounds doubtless implies its advantage both in surgery and in prompt recovery from small internal hemorrhages which may be of everyday occurrence.

By the middle thirties so much evidence had been recorded to show the advantage of liberal amounts of vitamin C that most students of the subject were agreed that it was desirable to keep the body approximately "saturated," i.e., to maintain such a blood-plasma level as is not permanently raised by increasing the level of intake. Both the intake level required for maintenance of approximate "saturation" and the concentration of vitamin C in the plasma

of the "saturated" body are subject to considerable individual physiological differences. This is regarded as another reason for setting general allowances at generous levels.

Though the healthy, youthful, human body has a wide flexibility in adjusting itself to weeks or even months of shortage of vitamin C, it does not follow that chronic shortage can logically be a matter of indifference. Rather it appears that to keep the body well supplied with vitamin C is one of the conditions conducive to conservation of the characteristics of youth.

Recent reports from as widely separated parts of the world as Australia and Sweden and including some of the United States (where average consumption may be fairly satisfactory although there are great disparities in distribution) show that while scurvy is now a "solved problem" so far as empirical scientific explanation is concerned—and the nutritional status of uncountable millions of people has doubtless been improved by the use of this knowledge—we have not yet solved the social-justice problem of equitable distribution of the antiscorbutic fruits of the earth to all, or even to nearly all of the earth's people.

We who have the knowledge have not yet fully performed our function of *effectively* explaining that fruits and fresh vegetables are not luxuries but good nutritional investments.

The British physician Martin has also published a plea that those who prescribe diets for such other conditions as, for instance, stomach or duodenal ulcers, shall not forget, for too long a time, to provide each patient with an adequate supply of vitamin C in some way.

In the middle thirties L. J. Harris wrote that the trend of experiment confirmed the impression that deficiency of vitamin C may cause a marked diminution in resistance to certain types of infection.

In this connection Harris cited the finding of McConkey and Smith that vitamin-C-deficient guineapigs developed ulcerative intestinal tuberculosis after experimental administration of tuberculous sputum whereas, under strictly parallel experimental ex-

posure, controls receiving normal amounts of vitamin C in their food did not. Harris also emphasizes Rinehart's view that subclinical scurvy may constitute "the rheumatic tendency" which with the added factor of infection causes the development of rheumatic fever and, possibly, the closely allied condition of rheumatoid arthritis.

Promptly upon King's identification of vitamin C, chemical methods were devised for measuring its concentration in urine and thus ascertaining the amount excreted per day through the kidneys. For an adult, an average daily urinary excretion of about 13 milligrams of ascorbic acid has been considered by some investigators to indicate that the vitamin C intake has been barely enough to provide the minimum physiological requirement, while the excretion of 20 milligrams daily in the urine indicates a fairly low but perhaps adequate intake, and that an output of 40 milligrams indicated a liberal intake. A second step has been to measure the relation between increases of intake and the resulting increases of urinary output; and a third plan is to measure the concentration of vitamin C in the blood. A person whose blood shows about 0.6 milligrams (per 100 grams, milliliters, or cubic centimeters) of vitamin C is on the borderline between barely adequate and fully adequate vitamin C nutrition, and one whose blood has a value of at least 1.5 milligrams is likely to have excellent reserves.

Many investigators believe that optimal nutrition, the state of health which cannot be bettered by better nutrition, is best secured by giving all of the vitamin C that the body can hold. This state is commonly called saturation.

The paper by S. L. Smith in the 1939 Yearbook of the United States Department of Agriculture gave an excellent summary of the evidence up to its date on the relations of dietary intakes and bodily concentrations and stores of vitamin C, and their relations to health. The National Research Council's pamphlet "Recommended Dietary Allowances" has a section in which the corresponding evidence up to 1948 is excellently summarized and interpreted by C. G. King. The evidence strongly supports the view that increased

liberality of dietary intake of vitamin C brings the body correspondingly increased benefit up to levels several fold (perhaps tenfold) higher than those which are strictly necessary for the prevention of "classical" scurvy.

Thus during and since the decade of the 1930s there has been rapid progress both in our scientific knowledge of this vitamin and in appreciation of its good effects upon our life processes. The increased consumption of citrus fruits, tomatoes, and such green vegetables as broccoli, collards, kale, and turnip greens has enriched our dietaries in vitamin C content, and this improvement of our food habit should spread to all economic levels with important benefit to our individual and public health.

THE VITAMINS D

At the beginning of the decade of the thirties, Bills and his co-workers described fully and with precision the measurement of antirachitic potencies or values; at the middle of the decade Bills reviewed the knowledge of antiachitic vitamins up to that date, showing that at least ten such substances were known but that only two of them had become or seemed likely to become of outstanding importance; and this view still holds at the time this is written in 1949.

The two important forms of vitamin D (vitamins D_2 and D_3) show sufficiently different relative potencies (or antirachitic values) for rats and for chicks so that it seems worth while to recognize their existence by use of the term vitamins D; though most of what we have to say in writing about human nutrition can be said in the same terms as if there were only one.

In addition to the information given by Bills as noted above on sources of vitamin D, the reader may find interest in the paper of Eliot, Nelson, and the others on the antirachitic value of salmon oil, and that of Haslewood and Drummond on tunny (tuna fish) liver oil as a source of vitamin D.[5]

The *Journal of the American Medical Association* has especially

[5] See their papers listed in the Bibliography.

emphasized the fact that milk constitutes an exceptionally effective medium for the administration of vitamin D, so that the use of vitamin D milk should be especially encouraged.[6]

Accounts of the favorable influence of liberal vitamin D upon linear growth are given by Slyker, Hamil, Poole, Cooley, and Macy and by Stearns, Jeans, and Vandecar.[7]

This decade was rendered especially memorable in the history of vitamin D by the fact that in 1931 crystalline preparations of the substance were produced almost simultaneously in four different laboratories. But a discussion of the complex chemistry of the vitamins D would extend beyond the scope of this volume.

VITAMIN K

It was practically at the beginning of the decade of the thirties that the Danish investigator Henrik Dam found that a previously unknown substance in the diet is essential to the normal clotting of blood. He called this *Koagulations-Vitamin*, abbreviated in English to *vitamin* K.

It has since been found that it occurs naturally in at least two forms (vitamins K_1 and K_2), and also that several synthetic substances have similar properties.

As a large proportion of infants were found to be born with blood of low coagulation power, there has been and is a growing practice of insuring adequate blood-clotting power by administering vitamin K either to the mother before delivery or to the infant at birth.

Thus the development of the science of nutrition has resulted in still another service to the life process.

VITAMIN M, FOLIC ACID, PTEROYLGLUTAMIC ACID (OR GLUTAMATE)

It was also in the decade of the thirties that Day and his coworkers discovered vitamin M as something additional to previously known nutrients, yet essential to the dietary of the monkey. In-

[6] See paper by Jeans (1936) listed in the Bibliography.
[7] See their papers listed in the Bibliography.

dependently a substance which at the time was not chemically identified was found to be essential to chicks, and because of its noteworthy occurrence in leaves was named folic acid. Later a substance previously unknown but needed by some of the testing bacteria was also reported. And finally all three of these substances (or groups of substances) were found to be either identical or so closely similar that for most purposes (as with the vitamins D), they can be treated as merely variations of the same essential. This is called pteroylglutamic acid (or glutamate), from a contraction of its very long chemical name.

Whether considered as a normal nutrient or used as a therapeutic agent in some forms of anemia or as both, this promises to add still further to our resources for the improvement of human nutrition.

THREE DECADES OF DEVELOPMENT OF NUTRITION-CONSCIOUSNESS IN PUBLIC OPINION

As early as 1892 Mr. Nathan Strauss had established his well-known milk stations, and in 1906 the New York Association for Improving the Condition of the Poor organized the volunteer "working party" known as *The New York Milk Committee* with the declared purpose to create through education a public demand for a clean and safe milk supply for all, "to prevent unnecessary loss of infant life." Under the auspices of this standing committee, a special *Committee for the Reduction of Infant Mortality* was formed. It organized in 1911 a demonstration by public and private agencies in New York city and published the findings of work done in the ten largest cities of the United States to determine the value of milk-station work as a practical means of reducing infant mortality. A full report on that work was published in 1912, under the title *Infant Mortality and Milk Stations*, by the New York Milk Committee, 105 East Twenty-second Street, New York.

What follows immediately here is largely from that report.

In 1910 about *one fifth* of the deaths in the Registration Area of the United States occurred in the *youngest fiftieth* of the popu-

lation. That is, the death rate was about ten times as high in infants as in the general population.

About one half of the deaths of infants were reported as resulting from diarrheal and wasting diseases. As a result of the demonstration of the summer of 1911 the infant mortality in New York city during the summer and early autumn of 1911 was very greatly diminished. And this was accomplished so largely by educational methods that the benefit has been permanent.

The milk stations became both all-round infant welfare centers and agencies to assist mothers in the care of preschool children. The Committee for the Reduction of Infant Mortality emphasized the benefit thus brought to the older children at the same time as to the infants.

One of the direct results of the 1911 demonstration was the action of the Board of Health in raising the number of milk and infant welfare stations in New York city from 15 to 55.

The indirect results were, of course, still more far-reaching—helping greatly to carry scientific conviction of the importance of milk and other "protective" foods to both the Health Departments and the voluntary social agencies of other communities, first throughout the nation and then gradually to other peoples as well.

That public health surmounted the unprecedented economic depression of the 1930s as well as it did, was doubtless largely, and probably mainly, because of the wide diffusion of nutrition education (both in schools and directly in homes) which had come about during the first three decades of the century.

The two great fundamental causes of infant mortality are in one sense poverty and ignorance; in another sense, faulty nutrition and insanitary surroundings. Measures to alleviate these conditions aim, of course, to improve both nutrition and sanitation and there can hardly be a very exact determination of the relative parts played by nutrition and santitation when infant mortality is reduced by such improvement of conditions as was made through the work of the milk stations, yet it was doubtless a sound expert opinion when, as already briefly noted, the late Dr. Mary S. Rose wrote in 1916,

in the Preface to her *Feeding the Family*: "While many things contribute to health,—sleep, fresh air, and exercise, for instance,—the foremost consideration is food." And by 1924 her reference to food became more specifically nutritional as she wrote: "Since the publication of the first edition there has been a continuous stream of contributions to our knowledge of the vitamins which has emphasized their importance in raising the diet from the 'subsistence level' to an actively health-promoting one."

In the 1935 edition of her book entitled *Nutrition Work with Children*, Dr. Lydia J. Roberts wrote that, during the preceding two decades particularly, evidence had been accumulating in nutrition laboratories throughout the world that the growth of the young, their ultimate size, the structure of bones and teeth, the ability to withstand infection, the attainment of full physical vigor, the length of life—all are dependent in large measure upon nutrition.

And, after commenting on the slowness of change in matters of food habit, she pointed out that, nevertheless, rickets in its severe form was, by 1935, rapidly decreasing, scurvy was largely reduced to the subclinical type, and increasing groups of American children were showing improved growth and other indications of superior nutrition.

The nutrition movement of the middle thirties, then, was an endeavor to secure the more prompt and effective incorporation of the results of nutrition research into the daily food habits of increasing proportions of our people.

Roberts considered that the first and most difficult step in spreading the benefits of the newer knowledge was to convince the people that there was need for nutritional improvement.

The fruitfulness of this work of Dr. Roberts and of the (partly earlier and partly simultaneous) work of the late Dr. Mary S. Rose was enhanced by the fact that a fertile soil had been prepared in the infant welfare work of the early years of the century.

Then in 1937 came the publication of the League of Nations' *Final Report* of its *Mixed Committee on the Relation of Nutrition*

to Health, Agriculture, and Economic Policy; and the prominent featuring of nutrition in the 1939 Yearbook of the United States Department of Agriculture.

In the League of Nations the delegation from Australia had sought to "marry health with agriculture"; the work of Dr. E. Burnet and Dr. W. R. Aykroyd, while emphasizing the importance of nutrition as a physiological problem, had pointed out that it must also be a matter of concern to both public health officers and economists; the International Labor Office had published a general report on *Workers' Nutrition and Social Policy*. The intention of the League's Assembly, in deciding upon an international enquiry into the relations of agriculture, economic policy, health, and the science of nutrition, was not to supply governments with ready-made or uniform solutions of their nutritional problems, but rather to enable them to work out solutions for themselves and also to put public opinion in possession of information on the relation of nutrition to health.

While the League's attempt to carry its nutritional message to people untrained in science led to the oversimplification of dividing entire food supplies into only the two categories of fuel foods and protective foods (whereas from five to ten categories seem essential to a fully satisfactory application of today's knowledge), yet this 1937 report gives an effective general impression of conditions at that time. Thus to a brief account of the English work cited as Corry Mann's in our preceding chapter there was added by the League of Nations committee the report that milk given twice daily for six months to Paris school children resulted in a 40 percent extra gain of weight in boys and 65 percent in girls. The report then adds that similar results had also been found in other countries, and that the bodily gain was as a rule accompanied by a reduction of minor ailments and infections and by "a definite improvement in vitality." After reviewing the improvement in vital statistics with improved economic conditions, this 1937 report states it as clear that if Governments can achieve for their peoples adequate levels of food

consumption, this will mean that further progress, fully equal to that made in the nineteenth century, can be made in increasing the quantity and raising the quality of human life.

It is still true, as this League of Nations committee pointed out in 1937, that the movement toward better nutrition has made considerable progress, but it has not gone nearly far enough.

The United States Department of Agriculture, which in an earlier Yearbook had stated regarding the nation's agricultural effort that "The goal is optimal nutrition," now devoted its 1939 Yearbook essentially to food and nutrition. In the Foreword, written by a student both of genetics and nutrition, we read:

"Probably 99 percent of the children of the United States have a heredity good enough to enable them to become productive workers and excellent citizens provided they are given the right kind of food, proper training, and ordinary opportunities. Fundamental to adequate training and decent opportunity is food. Fifty percent of the people of the United States do not get enough in the way of dairy products, fruits, and vegetables to enable them to enjoy full vigor and health, and a large number of them do not get enough because they cannot afford it. It is the duty of the farmers, the Government, the businessmen, and organized labor to cooperate to see that the children of these people are better fed than their parents were. That part of the book which deals with human nutrition is an effort to discover a scientific basis for coordinated action along this line. The Department of Agriculture publishes the book realizing that the science of nutrition is still very incomplete and that much new, vital information is being discovered every year. But a comprehensive knowledge of nutrition is far from widespread. We feel that it is wise to publish this book, in spite of its shortcomings, because it is comprehensive."

The following paragraphs abstract some of the main nutritional ideas of this Yearbook.

As Dr. Louise Stanley defines it, Nutrition has to do with the

use that living organisms make of food. All our foods, she points out, are directly or indirectly derived from plants. "Man is the combined product of inheritance and environment. Food is the environmental factor that most directly controls his physical development; and it probably plays an important part in setting the pattern of nervous and emotional responses that make up the total personality."

Furthermore, as Dr. Stanley points out, the twentieth-century science of nutrition provides a rational basis for food selection that, applied through planned food production, education in the use of food, and more equitable distribution, "can be used to increase the length and improve the quality of human life."

According to Dr. L. E. Booher and Dr. C. M. Coons, we are only beginning to realize the possibilities not only of preventing certain diseases but of promoting positive health, efficiency, and long life through good nutrition. They hold that the most frequent faults in American dietaries are shortages of mineral elements and vitamins, largely because of too great dependence upon artificially refined foods. "Physicians and nutritionists are also beginning to realize that the effects of a prolonged slightly faulty diet may not be detectable for years . . . Education in correct dietary habits so that people may learn how to provide themselves with liberal amounts of the protective foods is a very important factor in improving our national health. . . . The adult body has the capacity for carrying fairly large mobile stores of calcium. To be optimum a diet must keep these reserves well filled at all times." They hold that, whatever the detailed scientific explanation may prove to be, observations upon children have established the fact that dental caries is less prevalent among children who have been fed in accordance with the newer knowledge of nutrition. Such a food habit is also best for the conservation and strengthening of the body's natural powers of resistance to disease. (This, of course, is not to be confused with bacteriologically acquired immunity to specific infections.)

In the same Yearbook Dr. Hazel K. Stiebeling recalled the animal experimentation of McCarrison in which by differences of diet alone he paralleled the contrast of the "stalwart resolute races of (what was then) the North of India" with the "toneless, supine, and poorly developed people" of its South and East. Food habits are notoriously slow to change, yet Stiebeling showed that during the previous 50 years there had been an increase of almost 50 percent in the proportion of food calories taken in the form of milk and its products, fruits, vegetables, and eggs.

With knowledge and nutrition-consciousness more widespread now than ever before, it should be possible to discriminate among the trends of the past 50 years. This need not mean a change of pattern, for much good can be accomplished by simply shifting the emphasis or making gradual adjustments, to more or to less, within the accustomed pattern.

Chief among current motives for changing dietary habits are (according to this Yearbook) fashion and health. "In food as in clothing, there is a tendency to copy the styles set by the accepted leaders in social groups." The body's ability to carry reserves of nutritional essentials frees us from the tyranny of meeting exactly the physiological requirements from day to day. But this also means that the constructive possibilities of the building of higher health through the use of nutritional knowledge in the guidance of daily food habits are not usually demonstrated with dramatic promptness in human experience. The individual or family who would enjoy the health benefit of the newer knowledge must either acquire a modicum of this knowledge by study or accept the guidance of the scientific workers in the field of nutrition and food values. "Widespread improvement in nutrition would result if present knowledge . . . were widely disseminated and put into common practice." And this need not mean any such break with fashion as the exclusion of any familiar food from the dietary. The health benefits can be gained by simple adjustments of relative amounts within the accustomed patterns or fashions of American food habits.

There is an excellent account by S. L. Smith in this Yearbook

(pages 235–55), of the discovery of vitamin C and its functions, and of the amounts required in human nutrition under different conditions and to meet different criteria of adequacy.

In the same Yearbook (page 265) there is a paragraph on the riboflavin contents of American dietaries which seems likely to mislead the reader. It ends with the statement: "Probably human diets that include a wide variety of natural foods provide a liberal margin of riboflavin." It would seem more accurate to say that probably most such diets provide amounts of riboflavin larger than needed for prevention of visible deficiency but less than the amounts needed for best long-run results. For optimal results in the long run of a lifetime one should not only eat a variety of natural foods but also pay reasonable attention to giving a large place in the dietary to foods like milk, cheese, broccoli, collards, kale, and turnip greens which are good sources of riboflavin, calcium, and vitamin A. This is because of the present strong evidence that the life processes (and so the life history) can be improved by food habits which keep the intakes of these three nutrients, and probably also of vitamin C, at levels providing more liberal margins above minimal adequacy than are called for in the cases of most other nutrients.[8]

Thus when in 1940 and 1941 the United States began examining all its young men, as to fitness for military service, the revelation of shockingly high percentages of unfitness came to our people at a time of already unprecedented nutrition-consciousness.

True, there was doubt whether reports of higher percentages of rejections than in the First World War meant physical deterioration during the intervening quarter century or advancing standards in diagnostic methods, equipment, and interpretation. And it seems safe to say that the more this question has been studied the more probable it has appeared that the increase in percentage of rejections was chiefly the result of more delicate methods of detecting defects, and resultant higher standards for acceptance into the armed forces. Yet there was no room to doubt that a disturbingly large proportion

[8] See also the discussion by King in the "Recommended Dietary Allowances" (1948 ed., obtainable from the National Research Council, Washington, D.C.), pp. 19–20.

of our people were failing to realize their full potentiality of health and efficiency, and that malnutrition was a factor in a large proportion of these failures.

Such a situation would in any case have been incongruous with the food-production capacity of our country; and with the then growing probability that our nation would be drawn into the Second World War there was urgent need that the new knowledge of nutrition be put to work promptly for the betterment of our positive health and efficiency. The President of the United States called the country's first National Nutrition Conference for Defense to meet in Washington in May of 1941.

ADVANCE IN WELL-BEING

"To marry health and agriculture" was a slogan especially urged during the thirties by the Australian delegation in the League of Nations. Perhaps the first scientific and practically applicable development of the idea was that of Dr. Hazel K. Stiebeling in Miscellaneous Publication No. 183 of the United States Department of Agriculture. In this and other papers Stiebeling pointed out that the consumer, knowing that much knowledge of the relations of food to health had been accumulated, wished to get the best return for the money spent for food. And that the producer wished to know what consumer demand could be expected. Improving the diet should both improve the health and efficiency of the population and foster the types of agriculture which practice wise utilization of land for the well-being of the country as a whole.

Throughout the decade of the thirties the League of Nations Health Organization was emphasizing the importance of the food we consume to the nutritional status of our bodies and our resulting health and efficiency. It was in this connection that Lord Astor put the new emphasis in the few simple words: "It isn't only that there be enough food; but that there be *enough of the right kinds of food.*"

The League of Nations' *Mixed Committee on the Relation of Nutrition to Health, Agriculture, and Economic Policy* was ex-

pected to report, as Dr. Isabella Leitch put it, on "the nutritional needs of the human being as a basis for a planned agriculture." And she considers it "particularly noticeable that the League of Nations' allowances for vitamins are so far below those of Stiebeling and the U. S. National Research Council." She calls attention to the fact that the 1937 Report of the League's Technical Commission does not make it clear whether the vitamin allowances discussed were in general intended to be taken as minima "to prevent the least impairment of function" or as optima "above which further dietary additions do not enhance the well-being of the body."

The phrase just quoted may be deceptive in its appearance and sound of simplicity. For in general, only very long-term feeding experiments, under conditions of the most carefully quantitative and comprehensive laboratory control, can show *conclusively* whether or not the well-being of the body will (in the long run of a lifetime) be at all enhanced by raising levels of intake which already look adequate as judged by the standards hitherto accepted. The margins of potential further benefit may well be very different with different nutrients.

CHAPTER VII

In the Second World War

IN THE PRESENT CHAPTER we are to consider the nature and the effects of the demands made upon the young and still growing science of nutrition by the Second World War and its immediate aftermath of struggle for economic recovery and for the construction of a durable peace.

Considerably before the United States was technically a belligerent, the Second World War was affecting our food economy and accentuating the interest in nutrition as an important factor in health and efficiency. In fact, one cannot say exactly at what time or through what circumstance our food affairs first felt the impact of the war; too many circumstances were becoming influential at about the same time. The export market for American-grown food (which had shrunk to relative insignificance under the economic and political conditions of the period between the two world wars) was, when Europe went to war, greatly expanded, while at the same time the men who had been employed in American agriculture were being drawn from the farms to the manufacture of munitions. Also a large proportion of our young men were being sent to military training camps where they produced no food and probably consumed more than most of them had eaten at home. The fact that many were rejected as unfit for the armed forces did not check the number drafted; but rather tended to extend the age range of the draft. True, a further study of the data showed that the average of the young men examined at (say) about 1940 was taller than the average for the same age at the time of the First World War; and the greater percentage of rejections at the later time may have been the result of higher standards and more delicate diagnostic methods. Yet it also was apparent that a large proportion of our young people had not been reached in any adequately effective way

by the knowledge of nutrition which was available at the time they were growing up.

Consciousness of this fact came at the same time that earnings of many families were increased by fuller employment at higher pay in the production of wartime supplies. And simultaneously there was a growing realization that the highest possible health, fitness, and efficiency were needed both in our armed forces and in agricultural and industrial production.

THE NATIONAL NUTRITION CONFERENCE OF 1941

As we have seen, the President of the United States called the first National Nutrition Conference to meet in Washington in May 1941. The Vice-President in addressing the Conference suggested a series of three goals for the nutritional improvement of the people of the Nation: (1) Eradication of nutritional deficiency diseases—"we do not have yellow fever any longer in this country, neither should we have pellagra." (2) A great decrease of those infectious diseases like tuberculosis, the prevalence of which depends largely upon nutritional condition. (3) The building of nutritional status in our people to the level that supports "health plus." "Whether it be children, whether it be workers, whether it be soldiers, the first step toward a happy, confident attitude is an abundant supply of the right kind of food. On a foundation of good food we can build almost anything. Without it we can build nothing."

There were many and strong indications of an unprecedented confidence in the potentialities of nutrition for the building of higher health and efficiency.

The officers of government and other speakers who addressed the Conference repeatedly emphasized the great progress recently made by the science of nutrition and the importance of full application of the new knowledge in order that all our people might face the emergency with the highest possible health and efficiency.

Dr. R. M. Wilder, then chairman of the Committee on Food and Nutrition of the National Research Council, emphasized the fact that the Nation was faced with a serious problem of malnutrition;

that despite a so-called surplus of foods a great many of our people were not receiving the fare they needed for strength of mind and body. "The hopeful and challenging thing," he said, "is that we now have the scientific knowledge, the means, and the national will to do something about it."

Dr. M. L. Wilson emphasized the use which would be made of the knowledge which had been gained through a quarter-century of nutritional research. "We are," he said, "a well-fed people compared with the dietary levels in most parts of the globe. But we are not well fed in relation to the productive potentialities of our land and labor . . . we have the agricultural capacity to provide a good diet for the whole population."

Dr. J. R. Murlin cited the success of good feeding, together with suitable exercise, in the building up of health and fitness in men who had been rejected as unfit for military duty.

Another speaker quoted Lord Astor's aphorism: "It is not only that people must have enough food; they must have enough of the *right kinds* of food." And the fact was emphasized that: "How to bring enough of the protective foods into the dietaries of all the people is both an economic and an educational problem."

The Secretary of Agriculture told the Conference that "so far as production is concerned, existing national policy has given us a more flexible, more adjustable, less haphazard type of agriculture. We not only have the resources to produce all (that) our people need for better nutrition; we also have the methods. . . . From the standpoint of distribution, existing agricultural policies are no less in line with the goal of this Conference."

The Secretary of Labor stated that, "One of the hopes of this generation is to be able to make available to all our people the goods they need for satisfactory living." And that, "The most indispensable of these goods are the foods required for adequate nutrition."

At the same time it was recognized that there is much to be done to make the new knowledge effective. Dr. H. K. Stiebeling reported that a large proportion of the families in the United States "have food supplies that fail to furnish the quantities of nutrients recom-

mended by the National Research Council's Committee on Food and Nutrition." This is shown by comparing these allowances with the nutritive value of diets studied in the large-scale surveys made during the years from 1934 to 1941 by Federal agencies. Unfortunately we have no large-scale clinical studies to give us direct evidence of the prevalence of malnutrition, but the small-scale studies that have been made corroborate the implication of the dietary studies that suboptimal nutritional status is of frequent occurrence. In Stiebeling's opinion, many families with grossly inadequate diets recognize that they would fare better were their diets improved. But a large proportion of the millions of families with moderately poor diets are unaware that food could make a difference, and that their strength, alertness, working efficiency, and joy in living could be enhanced through improved nutrition. To raise levels of nutrition in this country, it is necessary to have (1) a widespread appreciation of the importance of adequate diets, (2) a working knowledge of what constitutes an adequate diet, and (3) economic resources that would enable people to acquire adequate diets.

The Surgeon General of the Public Health Service summed up in part as follows: ". . . given the national will to do it, we have the power to build here in America a nation of people more fit, more vigorous, more competent; a nation with better morale, a more united purpose, more toughness of body and greater strength of mind than the world has ever seen. . . . The food and nutrition experts will continue and increase their efforts. Theirs must be the responsibility for teaching citizens what a better diet will mean to every American, in terms of a strong body, a more alert mind, greater resistance to disease, longer life, greater vigor and a better chance for happiness. Substantial governmental aid to agriculture will be directed, I hope, toward adapting our productive capacity more directly to meet the nutritional needs of our people."

General Findings and Recommendations of the Conference to the President of the United States included the following:

"I. The great . . . advances in our knowledge of nutrition in recent years have made it clear that the food an individual eats

fundamentally affects his health, strength, stamina, nervous condition, morale, and mental functioning. It is of paramount importance to the normal growth, development, and health of children. In view of these proven facts, it is vital for the United States to make immediate and full use of the newer knowledge of nutrition in the present National Emergency. . . .

"II. The newer knowledge of nutrition should be used not only for the benefit of our armed forces, who must of course be adequately fed, but for that of all workers in industries directly and indirectly related to defense, and also for the civilian population as a whole. . . . The food provided for women and children is as important to the future of the nation as that provided for defense workers.

"III. Recent dietary studies among large groups representative of the people of the United States, clinical studies among smaller groups, and the examination of men called up for military service show clearly that poor diets and malnourishment are widespread in this country."

. . .

"The United States is probably the best fed Nation in the world today, but we cannot afford to judge ourselves by external standards. We should judge ourselves by the standard of our own potentialities —our resources in food, in technical developments, in scientific knowledge. By that standard, we fall far short of our goal."

Several months before this conference, the National Research Council had reestablished its Committee on Food and Nutrition (now named the Food and Nutrition Board) and assigned it the duty of defining adequate dietaries in terms of actual quantities of nutrients. The resulting table of figures, called Recommended Dietary Allowances, which provides for seventeen categories of people according to age, sex, and activity, was reported to the National Nutrition Conference in May, 1941, and was slightly revised in 1945 and 1948. The table of Recommended Allowances with its direct footnotes is reproduced in Chapter XII. It is also obtainable

from the National Research Council (2101 Constitution Avenue, Washington 25, D.C.).

The United States Department of Agriculture in its Miscellaneous Publication No. 546, *Principles of Nutrition and Nutritive Values of Food,* compared the amounts of nutrients in that part (about three fourths) of our national food production which was available for civilian consumption in 1943 with the National Research Council's Recommended Allowances then current. Both were computed to the same *per capita* basis. Of each of the eight well-known nutrient factors for which we are dependent upon our food, the amounts estimated as available for civilian consumption under the wartime rationing of 1943 were higher than the Recommended Allowances: Calories by 22 percent; protein by 46 percent; calcium by 10 percent; iron by 31 percent; vitamin A value by 41 percent; thiamine by 60 percent; riboflavin by 5 percent; ascorbic acid (vitamin C) by 39 percent. Here the smallest margins are in respect to riboflavin with 5 percent and calcium with 10 percent. All six of the other factors show much safer margins ranging from 22 to 60 percent. Thus even when a quarter of the food produced was being diverted to our Allies and our armed forces, the civilian population of the United States still had a food supply which carried very generous margins over nutritional needs with respect to a large majority of the nutrients.

It is noteworthy, too, that United States farmers can produce, in response to consumption demand, over one third more food in nutritive values than the average level of 1935–39, even with the current practice of turning enormous amounts of grain into meat at great expense of nutrients.

What the level of food production will be in the year in which this is read will depend (aside from the weather) predominantly upon the level of demand (for combined home consumption and export) which the farmers at planting time had reason to expect of the coming year. The Department of Agriculture offers guidance to the farmers partly in the form of its annually announced production goals.

It has been asked whether in wartime the combination of patriotism and high prices may have made the farmers "push their land harder" than would be best for either their own or the nation's interest as permanent peacetime practice. It is true that some soil-conserving measures may have been in part postponed during the war; but with the return of young farmers from the armed forces to the farms, and the restoration of manufacture of farm machinery and supplies to full normal volume, it is probable that soil conservation can be and is being resumed without necessitating much lowering of wartime production levels. Especially is this probable because of the fact that increased production has been made possible by research and that further progress can logically be expected along similar lines when a more settled peace has made possible a fuller manning of civilian research projects, and of the farm operations which they guide.

Farmers appreciate new methods by which they can increase their production; and, on the whole, it is logical to expect that with adequate demand from consumers farmers can and will continue, through as long a future as we can foresee, to increase their production by use of the improvements worked out by agricultural research. Certainly our national resources for food production are much more than sufficient to provide the Recommended Allowances for all our people.

In presenting the Recommended Dietary Allowances to the May 1941 Conference, Dr. R. M. Wilder, then Chairman of the National Research Council's Committee on Food and Nutrition, said: [1]

"The allowances for specific nutrients are intended to serve as a guide for planning adequate nutrition for the civilian population of the United States. . . . The quantities were planned to provide a reasonable margin of safety, but it is recognized that they may not always be attainable under all circumstances. These allowances are to be distinguished from the minimum requirements set up by the Food and Drug Administration for use in connection with the

[1] Proceedings of the National Nutrition Conference for Defence of May 1941. Government Printing Office, 1942. The Recommended Allowances of 1948 are discussed in Chapter XII of the present book.

labeling of foods. . . . The allowances for adults are given for the 70 kilogram man and the 56 kilogram woman at three levels of activity. They will need to be proportionately increased or decreased for larger or smaller individuals. . . . The allowances for children are given by age groups, and for boys and girls separately after 12 years, since from that age the growth curves and levels of activity for the two sexes differ. The values given are in each case for the middle year in the group and represent amounts needed for children of average size and activity. The needs for individual children may be proportionately larger or smaller depending upon size and activity. . . . It should be remembered that the amounts of the various nutrients provided for in these recommended allowances, with the exception of vitamin D, can be provided through a good diet of natural foods, including foods like 'enriched' flour and bread which have been improved according to recommendations of the Committee."

CHANGING WARTIME FOOD SITUATIONS IN CANADA, THE UNITED KINGDOM, AND THE UNITED STATES

Canada, the United Kingdom, and the United States set up the Combined Food Board in pursuit of the declared policy of these three nations to make common cause in meeting the food problems of the Second World War. A joint committee of that Board published in December 1944 a report on *Food Consumption Levels* in the three countries, which may be abstracted as follows:

Of milk in all forms (including cheese but not butter) all three countries were consuming more in 1944 than before the war. Of meats the United Kingdom was consuming considerably less than prewar quantities while Canada and the United States had not lowered their per capita meat consumption. They were consuming about 50 pounds per capita per year more than the United Kingdom. Of eggs the supply in the United Kingdom could only be kept up by a large (though doubtless reluctant) substitution of dried eggs for fresh, while in Canada and the United States there was no decrease in the per capita supply of fresh eggs. The reason that so many

people in Canada and the United States found it difficult to buy their accustomed number of eggs was that so many other families, with increased incomes from war wages, were competing for the eggs in the markets. Of fats and oils in the prewar period the United Kingdom consumed the most per capita, and Canada the least. In 1944 this was reversed. Canada alone had been able to maintain its prewar level of consumption of fats and oils. In the United Kingdom "there was a drastic drop in butter supplies in the war period, and one of lesser proportions in the United States." Of sugar Canada and the United States were consuming in 1944 about 10 percent less sugar than in the prewar period, and the United Kingdom about 30 percent less. Of breadstuffs and of potatoes, the United Kingdom was consuming increased amounts under war conditions while Canada and the United States were not. Of vegetables the United Kingdom had substantially increased its production and consumption and this had been a large factor in the nutritive value of its food supply.

The amounts of nutrients from all sources available per person to the civilian populations were estimated to have been as shown in Table 8.

It will be seen that at no point did the United Kingdom's civilian food supply of 1944 fall materially below that of 1934–38 while at some points it is materially better. This improvement and the more equitable distribution together account for the better health and lower death rates of the war years. Among the people of the United Kingdom, practically none were so badly fed during the war as had been many of the poor before the war.

According to the official estimates, here summarized in Table 8, the civilian populations of Canada, the United Kingdom, and the United States all increased their per capita consumption of protein in the war years represented by 1944 as compared with the prewar years, 1934–38 or 1935–39. Doubtless this is to be explained chiefly by the high place traditionally given to meat in these three countries together with the fact that in all of them fuller employment

and higher wages increased the purchasing power of a large proportion of families during the war years. Scientifically and medically interesting findings in the biochemistry of the proteins and their amino acids have to some extent been capitalized to reinforce the high-protein tradition; but the careful quantitative experiments of Hegsted, Tsongas, Abbott, and Stare have shown clearly that the prewar levels of protein consumption in these countries were far above any sound scientific estimate of even the optimal requirements of normal nutrition.

TABLE 8

NUTRIENTS AVAILABLE FOR CIVILIAN CONSUMPTION PER CAPITA IN CANADA, THE UNITED KINGDOM, AND THE UNITED STATES

	CANADA		UNITED KINGDOM		UNITED STATES	
	1935–39	1944	1934–38	1944	1935–39	1944
Food Energy (in Calories)	3182	3435	2987	2923	3236	3367
Protein (in gm.)	90	106	80	87	89	99
Fat (in gm.)	124	141	129	117	129	139
Calcium (in mg.)	879	1050	683	1037	885	1017
Iron (in mg.)	15.0	19.7	12.4	16.3	14.2	18.7
Vitamin A value (in I.U.)	6162	7154	3831	3773	6804	7389
Ascorbic acid (in mg.)	60	70	101	123	105	122
Thiamine (in mg.)	1.96	2.48	1.17	1.99	1.77	2.61
Riboflavin (in mg.)	1.93	2.33	1.56	2.09	1.97	2.61
Niacin (in mg.)	17.0	21.5	17.5	19.7	15.7	21.4

In the case of fat the peoples of Canada and the United States, but not those of the United Kingdom, consumed more in 1944 than in the prewar years. Wartime blockade and reduction of shipping made the shortage of fat in the United Kingdom inevitable, while Canada was able to keep the wartime supply above the prewar level by means of adjustments similar to those used in the United States as described below.

EMERGENCY FOOD ADJUSTMENTS IN THE UNITED STATES

The virtual cutting off of our importation of fats in the winter of 1941–42 called for immediate emergency action. To meet the impending shortage the government took measures to stimulate increased production of fats in two main ways: by intensified rearing and fattening of swine, and by increased cultivation of our oil-yielding crops of soybeans and peanuts.

Increased production of fats through raising more swine could be more quickly effective and offered the added inducement that there was a large market for pork: for our armed forces, for shipment to our allies, and for civilian consumption within the United States by families who never before had been in a position to buy as much meat as they would have liked to eat. Many families in wartime enjoyed largely increased purchasing power because employment was increased, wages were higher, and often the family increased its number of wage earners under the combined pressure of patriotism and high wage rates. With such active markets for pork and lard and the government's offer of support prices, the annual pig crop in the United States increased from 85 million in 1941 to 105 million in 1942 and to 122 million in 1943. But by the middle of 1943 it was clear that we could not continue to support such a rapidly growing swine population. The latter had been increasing even before 1941 and in the same five years in which the people of the United States had increased about 6 percent, and its dairy-cattle population about 8 percent, its swine population had increased about 68 percent. Or in a somewhat shorter time and in still simpler round figures, the swine [2] population had jumped 50 percent while the human population and its foster mothers the milk cows were increasing about 5 percent.

The rapidly increased numbers of swine (and of poultry) was reducing the nation's grain reserves to a dangerously low point. Also

[2] In the terminology of those who have most to do with them, pig is *not* a politer name for hog; "pigs are infants." The one word that clearly covers both the infants and the adults of the species is swine.

the support prices offered to encourage the rearing and fattening of hogs was making it more profitable for the farmers to feed their corn to their swine than to send it to market so that for a time there was actually a dearth of corn and its mill products in the channels of human consumption. Fortunately there was a succession of good crops of grain so that the competition of the swine did not endanger the supply of the staff of life of the poorer people over large areas or for long. But even a limited experience of a real shortage of grain in the United States convinced us that incentives should be so adjusted that the feeding of grain for the production of extra meat shall not unduly add to the difficulty of the low-income family's problem of daily bread.

In April, 1944, on the basis of a report of its Food and Nutrition Board, the National Research Council issued a statement entitled, *How We Can Share Our Food and Maintain Good Nutrition At Home.* In a discussion of the food situation and the Government's production goals, this National Research Council statement included the following recommendation which bears directly upon and specifically illustrates the question of choice of food:

"*Foods to be Emphasized under the Plan here Recommended.—Milk products* (with maximum practical use of all dairy products for human consumption . . .); *Vegetable fats* (including margarine fortified with vitamin A); *Meat of range and pasture fed* (as opposed to grain fed) *animals; Fish and shellfish; Eggs; Other protein foods* (dry beans, peas and soybeans, nuts, peanuts and peanut butter, soybean flour and grits); *Cereals* (bread and other wheat products, whole grain or enriched, oatmeal, corn meal and enriched grits); *Citrus fruits and tomatoes; Less perishable vegetables* (potatoes, sweetpotatoes, mature onions); *Green and yellow vegetables* (broccoli and kale, cabbage and brussels sprouts, carrots . . . green peppers, leaf lettuce, mustard greens, yellow fleshed pumpkin and squash, snap beans, turnip greens); *Locally grown fruits and vegetables generally.*

"These foods can augment the national nutrient supply most economically in terms of land, manpower, and equipment . . .

Among them are no foods which would be rejected by any considerable part of the population by virtue of food habits, taste, or religious taboos. This list of foods-to-be-emphasized . . . reflects what might well be a major administrative consideration in determining plans for production incentives such as support prices, subsidies, and transportation priorities."

This National Research Council statement was issued as applying to the 1944 situation and that of the duration of the emergency. In 1949 food shortages still exist for probably the majority of the world's people.

Whether we think in terms of individual and family *nutrition policy* or that of a nation or family of nations, any policy which sufficiently recognizes the newer knowledge of nutrition will give a growing place to fruits, vegetables, and milk in the food supply.

It will also be recognized that on practical grounds, these bulky, watery, perishable foods will be largely produced in the general regions in which they are to be consumed, and that the less perishable, more concentrated, foods, such as grains and breadstuffs, meats and fats, will enter more largely into overseas shipments than do the more perishable foods.

This policy should obviously appeal to common sense, both for the period of emergency food relief and for as long a future as we can foresee. For it is clearly sound economically and nutritionally. Countries suffering from severe food shortage will think first in terms of bread or its equivalent. And next in order of their desires, as to foods that we can send them, will usually come fats, or meats, or both.

We can confidently expect these facts to hold good both for the period of the present emergency and for the longer future as well; and during this time the liberated countries will be reestablishing their home production of fruits and fresh vegetables rapidly, and of dairy products as rapidly as circumstances permit. And, as conditions approach normal, it will become increasingly apparent that Europe can produce fruits, vegetables, and dairy products for its

own use as cheaply as it can import them; while grains (and perhaps the fuel foods generally) can, in the absence of artificial restrictions, be imported into Europe more economically than they can be produced there.

The elementary facts of nutrition that such matters of food habit or food policy involve are rapidly becoming widely known to people who thereby begin to realize, as no one could realize before, how the impoverishment and thwarting of human lives is largely the result of the limitations of the dietaries that are economically available to low-income families. Both materially and morally it would diminish the strain caused by disparities of economic condition, if the people of higher income would modify such food habits as are inherently expensive of food-production resources.

And similarly, goodwill between nations can be promoted, by our development of an attitude of willingness to make common cause in the winning (for all peoples) of freedom from want in peacetime, as the United Nations worked together for the winning of the war. Looking at the matter with the open mind of our professedly scientific age, one cannot fail to see the advantage to permanent peace of an amelioration of such disparities as that the per capita demand upon food-production resources is perhaps five times as great in some of the United Nations as in others. Our present knowledge of nutrition, of food technology, and of agriculture shows us how more equitable arrangements can be made; and it is clear that this better use of our scientific knowledge can strongly implement the development of such a widespread spirit of goodwill as is needed to insure the peace. The need which bulks largest in the American scene is to diminish the feeding of grain to meat animals. As a luxury line of food production this has catered to those of high purchasing power while increasing the cost of food for all. Now that it is coming to be more clearly understood that such extreme feeding of grain to meat animals necessarily makes it more difficult for the poor to have the bread and milk they need for health, it is time for an awakening of the sense of social justice of those who have been responsible for the luxury-consumer de-

mand that diverted an undue proportion of the grain crop into the fattening of meat animals in the hope of getting the higher prices of the conventional Choice and Prime grades.

Adjustment of the hitherto tradition-bound supporters of the luxury grain-fed grades to the true view that beef of the market grade of Good is good enough for anybody and for any occasion, would be a very real help toward today's objective of bringing nutritionally excellent food supplies within the reach of all.

In part this is a matter for governmental policy, and for education and advice by the national and international organizations. But the public opinion needed to support such a policy must be built up by the daily habits of individual consumers.

The consumer who is reasonably informed as to nutritive values and economic relationships will not wish to act against the public interest by demanding either an undue amount of a luxury grade of meat (or of meat, poultry, and eggs combined). The self-restraint in this respect which, for a time we exercised in order to release grain for hungry Europe, we should continue to exercise for as long a future as we can foresee, both for the sake of the better nutrition and health of our lower-income neighbors, and to ease the strain of economic disparities within the nation and between the nations.

THE UNITED NATIONS FOOD AND AGRICULTURE ORGANIZATION

The importance of national and international food policies based on the modern knowledge of nutrition was recognized by the priority given to food in the first gathering of representatives of the United Nations. This meeting, held in May and June, 1943, was named the United Nations Conference on Food and Agriculture.

It declared its belief that the goal of freedom from want of the food needed for health can be achieved for all.

The fact that there has not yet been enough food for the health of all people was characterized as "justified neither by ignorance nor by the harshness of nature."

The Conference made an earnest plea that not only should there be such expansion of the world economy as would make opportunity of employment for all, but also that steps toward freedom from want of food should not await the solution of all other problems.

The permanent successor to this Conference is the United Nations Food and Agriculture Organization (FAO).

But neither the FAO nor the United Nations of which it is an agency has authority or funds to enter into food production, or purchase and distribution, nor to subsidize increased production of the types of food of which larger supplies are nutritionally most desirable. Any one nation can enter into the control or guidance of its own food supply if and when it sees fit, while the United Nations and its agencies are limited to advisory and educational functions.

The international organizations are doing much to increase worldwide recognition of the importance of nutrition; national Governments acquired experience in their wartime problems of food supply which can serve the welfare of their peoples by bringing them a more nutritionally guided food supply in peacetime; and it is always to be remembered that with the ever wider and more effective dissemination of nutritional knowledge among consumers everywhere they will increasingly determine their food supply through their daily decisions as to what foods to use and how much of each.

Let us, then, in the following paragraphs glance at the national experience of the United Kingdom, and the consumer influence in the United States.

USE OF FOOD IN THE UNITED KINGDOM

Promptly upon the outbreak of the Second World War in 1939 the United Kingdom of England, Scotland, Wales, and Northern Ireland set itself austerely to the task of regulating its food affairs according to the guidance of nutritional knowledge. So well was this done, and so sound did the scientific knowledge prove itself in

nationwide practice that Britain was able to adapt herself to the reduction of the imported food on which she had grown to be so largely dependent, and to accomplish this adjustment not only without detriment to health or efficiency but with a degree of agricultural and military efficiency which was the wonder of the world, and with actual improvement in most aspects of the public health.

VOLUNTARY ADJUSTMENTS IN AMERICAN CONSUMPTION

Compared with the austerities of the British food control, Americans have been called upon for relatively little adjustment in their accustomed pattern of food consumption. And our resources for food production are such that if consumers use nutritional guidance in making the needed adjustments, they can improve the nutritional balance of the usual American family dietary at the same time that they are sparing liberal proportions of the foods most wanted abroad. Breadstuffs, fats, and meats are the foods most wanted by the hungry nations and most practicable for shipment to them. What we spare of these we can replace with fruits, vegetables, and milk, which are too bulky, watery, and perishable to be very practicable for shipment overseas, but which will make our own dietaries better when consumed in increased amounts. If we also diminish our demand for sugar so as to permit more sugar to be shipped to Europe instead of to us, this too can be replaced by increased use of the same protective foods, thus making our own dietaries still better.

Regardless of the financial terms on which our future shipments of grain or breadstuffs, fats, and meats to other nations are made, the fact that we are cooperating toward a more equitable distribution of the world's food among the world's people will add much to goodwill and to the prospects of durable peace.

Aside from the lack of adequate care of the soil itself, probably the world's worst waste from its food supply and food production resources is in the excessive feeding of grain to meat animals in the United States. True, we inherited from the older countries the fat-

stock tradition with its prejudice which assigns a lower market grade to grass-fed than to grain-fed beef. But this extravagance is doubtless practiced on a larger scale in this than in any other country. And the persistence of this custom, when the grain involved was so greatly needed to make bread for the hungry and to increase milk production, so aroused the disapproval of intelligent public opinion that we may reasonably hope for the mitigation of this extravagance that is at once so unscientific and so inhumane. And the main motive power to be brought to bear to accomplish the reform here needed is for individual consumers, in their daily choice of food, to direct their purchasing power into channels which shall help (instead of hinder) the bringing to an ever-increasing proportion of the world's people, of enough of the right kinds of food.

CHAPTER VIII

Principles and Practice

As nutrition is a relatively young science and its subject matter consists largely of facts of such recent discovery that some of their interrelationships are still in process of being worked out, there has yet been little attempt to distinguish between facts and principles in nutritional discussions. For instance, one of Atwater's many services to the public was the writing of a nontechnical bulletin which was published in 1902 under the title *Principles of Nutrition and Nutritive Value of Food.* In 1944, this same title was used by the United States Department of Agriculture for its Miscellaneous Publication No. 546. The purpose was in each case to furnish the public a nontechnical account of so much of the subject of nutrition and food values as everyone might well wish to know. But both in 1902 and 1944, the word *principles,* while used in the title, was scarcely to be found in the text.

And the word is used in a very flexible manner. One writer defines a scientific principle as a *general statement* which may require amplification in practice or adaptation to particular situations.

Another defines a principle as a *guiding concept*—one which may guide us in thought, or in action, or (better) in both. Whitehead wrote that a principle well assimilated is rather a *mental habit* than a formal statement.

In this chapter we use the word principle as nearly synonymous with general concept.

THE PRINCIPLE OF THE CONSERVATION OF ENERGY

This principle, prominent in physics and in science as a whole, means in its nutritional aspects that in the long run no one can spend any significantly larger amount of energy than he receives, almost entirely in the form of food, from his environment. The

usually assumed average moderately active man (physically active but not with heavy work), eats and spends about 3,000 Calories a day. If he spends more or eats less, the difference can be met for a longer or shorter time by burning some of the fuel he had previously stored in his body as glycogen ("animal starch") and fat. When that is gone he is obliged to be less active, lest he burn up so much of his own body substance as to be weakened by emaciation. But, as has been shown in earlier chapters, the body which has previously been abundantly fed may be carrying more reserves of both protein and fat than it needs for optimal efficiency. A brief report is given in Chapter IV of the experiments of Benedict and his co-workers with healthy young men, under well-controlled conditions, as to the possibilities of sustained human health and activity with substantially reduced food consumption. That work warrants some further discussion here from the viewpoint of the present chapter.

Throughout these experiments, the dietary was well balanced but its amount was markedly reduced until 10 to 12 percent of the initial body weight had been lost, after which the food restriction was such as to hold the reduced body weight about constant, the men living essentially the same mental and physical lives as before. Under these conditions, the combined effect of lowered body weight and lessened basal energy metabolism per unit of weight was such that the men lived on about 2,200 Calories a day or about two thirds their usual previous daily total food Calories. The lowered basal energy metabolism doubtless means some lowering of muscle tone, but the only detectable physiological cost of this adaptation of the body to a more economical use of food was a rather intangible lessening of animal spirits. In all tests applied, efficiency was well maintained. Somewhere between this two thirds of the original level of energy metabolism and the level only about half as high as this (the 1,000 Calories daily on which some victims of the war have been forced to live), the further effort of the body to reduce its energy output to meet the drastically inadequate intake results (when long continued) in the general apathy which has been found apparently extending to the brain as well as the muscles.

But the physiological adaptation, or even the pathological apathy, does not involve any departure from the principle that the body can spend no more than it has at some time received. The burning of a gram of fat still means the transformation of 9 Calories of energy in some form.

THE PRINCIPLE OF THE SPECIFICITY OF NUTRITIONAL NEEDS

All living things must spend energy and so must have fuel food; but the body also has its nutritional need of certain specific chemical elements and compounds. In the case of our own species, somewhere around 40 such factors are already known to be needed in normal nutrition. These needed nutritional factors are specific in two senses. Each is independently needed, to perform its own functions, and these nutrients are all needed by every member of the species, and usually in about the same amounts relative to age, activity, and bodily size.

However, we do not need to make separate dietary or food supply calculations as to every one of these 40 or so nutritional factors. The National Research Council's table of Recommended Dietary Allowances includes 10 of them with the assumption that food supplies which are satisfactory with respect to all these ten—calories, protein, calcium, iron, vitamin A value, thiamine, riboflavin, niacin, and vitamins C and D—may be trusted to supply the other nutritional needs without further planning.

Now this "N.R.C. yardstick," or any such fixed summary of quantitative nutritional needs, should be viewed in the light of the principle of nutritional flexibility.

It is quite true that, in the concise phrase of Lord Astor, sometime Chairman of the League of Nations committee on nutrition, "It isn't sufficient merely to have enough food; there must be enough of the *right kinds* of food." Yet the human body enjoys considerable flexibility in utilizing such foods as it may have as sources of the essential nutrients, and in using, to some degree, one nutrient in place of, or to "spare," another.

THE PRINCIPLE OF NUTRITIONAL FLEXIBILITY

Now that science has progressed to where the physicists themselves find machine-model analogies inadequate, we, in dealing with the chemistry of the nutrition processes, will best not think of these as analogous to machine processes; but rather as something more flexible.

A few illustrations may indicate the importance of these nutritional principles as guides in the practical problems of food management.

Benedict's study (mentioned above) of the body's adaptability to lowered food-energy intake may serve as one illustration of nutritional flexibility. In the case of protein, a high degree of potential flexibility has long been known to characterize the quantitative aspect of protein metabolism. The protein-sparing action of carbohydrates, featured in textbooks for nearly 40 years, need be but barely mentioned here. But attention should be called to the fact more recently emphasized by Youmans that the total caloric intake has an exceedingly important bearing on the adequacy of the protein supply. With a high-calorie diet the protein intake may be reduced safely to a very low level. With this in mind, and remembering the protein and energy values of breadstuffs and potatoes, we see that these can go a long way toward solving any possible problem of the adequacy of our supplies of protein foods.

Much experimental evidence published by several independent investigators during the past four decades has repeatedly emphasized the body's ability to thrive equally well throughout long periods of experimentation upon either low-protein or high-protein food, except, of course, that extra protein is needed for the special demands of growth, reproduction, and lactation.

As an example from the vitamin field, under some conditions a high intake of riboflavin helps the body to cope with a shortage of thiamine.

And as linking the proteins and vitamins, tryptophane has been found able to compensate for shortage of niacin.

Obviously, different chemical processes are involved in these different examples of nutritional flexibility. On the practical side, recognition of the ability of the body to coast over reasonable periods of shortage, one nutrient sometimes substituting for another to some extent, will enable scientifically guided food management to make full use of a given food commodity when abundant, and in case of rationing to allow scope for the judgment and preferences of individual consumers. This scientifically supported flexibility greatly facilitated the administration of rationing of meats and fats in the United Kingdom and in the United States during the Second World War. Doubtless the fact that some meats are so fat as to raise a real question where the line shall be drawn between meats and fats was one of the practical considerations which led to the adoption of rationing regulations which made meats and fats interchangeable so far as the ration-points required for their purchase were concerned. Other considerations were that both protein and fat stay longer in the stomach (other things being equal) than does carbohydrate food, and so they increase the sense of being full-fed, and postpone the return of the sense of hunger. When, later in the war, the same question arose in connection with the rationing regulations for the United States some nutritionists felt that meats and fats should be rationed separately because the nutritive functions of proteins and fat are in some respects so different. Those who took this view felt that the administrative decision to bracket meats and fats in rationing was too great a concession to administrative convenience, and were therefore alert to detect any evidence that such bracketing of meats and fats was objectionable; but no such evidence was forthcoming. Evidently, even in wartime, American family dietaries contained enough of both protein and fat so that if one family used its "red points" chiefly for fat it still had plenty of protein; and if another used them chiefly for protein, it still had enough fat for all nutritional needs, though there might be some feeling of shortage of fat from the culinary and psychological viewpoints. As these latter aspects appealed with different degrees of force in different families, the bracketing which permitted different

families to gratify their different tastes was helpful to the goodwill of consumers and was scientifically justified by the principle of nutritional flexibility.

THE PRINCIPLE OF THE NUTRITIONAL IMPROVABILITY OF THE NORM

For the sake of clearness, this principle is given explicit mention here. It does not, however, call for further exposition here, in view of the discussions in other chapters.

THE PRINCIPLE OF NATURAL WHOLES

The general principle that a natural whole may be something more than a mere summation of its parts has been developed philosophically by Jan Smuts under the term "holism" in his book, *Holism and Evolution,* and in an article on holism in the *Encyclopaedia Britannica.* This general principle applies with special cogency to some of the aspects of nutrition which we are considering in this chapter. The body's nutritional flexibility and improvability which we have been considering in the preceding chapters and sections is largely attributable to the fact that the body *as organism* is (in some important respects) something more than merely the sum of its parts because it is an *organized* whole and functions as such in nature. Some of the body's self-regulatory processes, as well as its power to reproduce itself, evidently involve potentialities beyond those of machines—even though they may be "explained" as "chemical mechanisms." In the main, the more-than-machine-like potentialities of the body result from the way (or ways) in which it is *organized as a whole.* Thus the nutritional flexibility which we have discussed above is in a very real sense a function of the body's organization as a natural whole. Moreover, the fact that many of our foods are also natural wholes has important bearings upon problems of human nutrition. When the problem of the enrichment of white flour and bread was under discussion all concerned were agreed that the amounts of thiamine, riboflavin, niacin, and iron should be set in accordance with nutritional

considerations; but there were still two angles of approach. Some favored such levels of enrichment as would make the enriched food carry its share of the amounts of these nutrients needed in human nutrition. Others favored "the principle of restoration," that is, of bringing the nutritive values in the fortified white flour back to the levels that were naturally present in the wheat before its milling. And this was more logical than may appear at first glance, for while nature does not make the wheat plant responsible for feeding us, yet it is a significant scientific fact that we have evolved in nutritional adjustment to the wholes which we found in nature and until recently ate as we found them. So wisdom lies in nourishing ourselves at least largely on natural foods.

The fact that we may not yet know all the nutrients that we need is a sound reason for keeping natural foods fairly prominent in our dietaries at all times, so that if there are nutritional essentials still unknown, our natural foods will supply us with them notwithstanding our ignorance of their existence.

THE PRINCIPLE OF NUTRITIONAL GUIDANCE IN FOOD MANAGEMENT

This general principle may well be the comprehensive and permanent guiding concept in the food-and-nutrition policy of every person. It makes life more interesting and worthwhile to each of us both as individual engaged in the nutritional engineering of one's own life for the full realization of its qualitative and quantitative potentialities, and as citizen of a world which wishes all its people to enjoy this same full realization of innate capacities and of cultivated ideals. To make use of the guidance of nutritional knowledge, and thus to build a life history of higher health and efficiency and of longer duration at full capacity than one would otherwise attain, is entirely compatible with full enjoyment of one's food. In fact, there is added enjoyment in eating when we know that it is not only the *consumption* of food but also the *construction* of a higher order of fitness, and so of a more satisfying life history.

The general idea and plan is to classify food commodities into

groups in such a way that the members of each group are sufficiently alike nutritionally to be fairly interchangeable among themselves while the groups differ from each other in worthwhile nutritional characteristics. Obviously, if the number of groups is too large the plan becomes unwieldy, while if the number is too small the contents of a given group may be too heterogeneous. Thus a fivefold grouping of all foods into—(1) fruits and vegetables; (2) milk and its products other than butter; (3) grain products; (4) meats, fish, poultry and eggs; and (5) fats and sweets—is logical and useful so far as it goes. But the first and the last of these five groups obviously invite subdivision. For, while fruits and vegetables taken as one large group can be characterized nutritionally as chiefly significant for their mineral elements and vitamin values, yet the nutritional functions of different vitamins and different mineral elements are so diverse that we now usually prefer such subdivision of fruits and vegetables as can take account of, for instance, vitamins A and C separately. And while fats and sweets are both fuel foods yet they differ so much both in economic origin and in dietetic utilization, that it seems more realistic to treat fats as one group and sweets as another. For these and related reasons it seems best for most purposes to divide foods into ten groups as in the following paragraphs. And as we are interested in good nutrition both for our individual selves and for as many other people as possible, our characterizations of these 10 groups of foods will consider both their nutritive values and something of their economic availability as well. For instance, some of our foods are "direct" or "primary" food crops obtained directly from the soil, while others are "secondarily derived" through animals. And again, some kinds of farm animals are much more efficient "converters" than others.

1. *Grain products* are still the staff of life in the sense that they bulk larger than any other food group in the nourishment of most people. They are also direct food crops capable of being brought directly into human nutrition, though in the United States and a few other countries a large share of the grain crop is usually fed to animals. The term *feed grain* (for animal feeding) in contra-

distinction to *food grain* (for human nutrition) is ambiguous. All sound grain of wheat, corn (maize), oats, rye, barley, and rice is suitable for human food and so should logically (scientifically) be counted as belonging to our *food resources*. It is not because of the small inherent differences between wheat and corn that the former is called food and the latter feed. Often a part of the wheat crop is fed to animals, and always a part of the corn crop is eaten by people. To call corn or oats or barley, or all of these, feed grains does not imply any unfitness of human food, but only an expectation that under our economic conditions most of the corn, oats, and barley will find a financially more profitable use in animal feeding, while our wheat, rye, and rice crops may be expected to be drawn predominantly into human nutrition. The grain products as a group are acceptable, convenient, and economical sources of a large share of our total food calories and protein. The nutritive value of their protein, and the extent to which they contribute to the mineral elements and vitamins needed in our nutrition depends upon how they have been milled and otherwise processed. The outer layers and the germ of the grain with (in the case of wheat, at least) the adjacent part of the endosperm, contain most of the mineral and vitamin values. They also furnish proteins which have a special value both directly and as a supplement to the otherwise inferior protein of the inner part of the grain used in making patent flour. "Enriched" flour and bread, or "restored" breakfast cereals have received back through the enrichment program a significant part but not all of the mineral and vitamin values previously lost in the milling process; but the supplementary protein value is not restored. Whole-grain or nearly or partly whole-grain bread, toast, or breakfast cereal is thus a nutritionally valuable part of the diet, now available in a wide variety of forms. This food group is thus worthy of high consideration both for its inherent nutritive values and because it facilitates the incorporation of milk in the diet. Bread, either whole-grain or enriched, and breakfast cereals, either whole-grain or restored, are excellent sources of thiamine; and it is largely due to these that recent evaluations of the American food supply

show such a generous margin of thiamine above the requirement of the Recommended Allowances as shown in Chapter XII. Most grain products have also a food value extending beyond their literally nutritive values in that they help to give a texture to the food mass which is advantageous to its orderly behavior in the alimentary tract and so promotes digestive comfort and good intestinal hygiene.

2. *Mature legumes and nuts* are a group which is fairly homogeneous in offering high protein and thiamine values, yet covers a wide range of cost and of place in conventional diets—from the cheapest of dry beans to the choicest of nuts, and including peanut butter, cheap, popular, and of high value but not yet adequately appreciated. The foods of this group are nutritionally important in supplementing the grains in their protein and B-vitamin values. The proteins of soybeans and peanuts rank with those of meat in the effectiveness with which they supplement the proteins of bread and of other grain products. Hence Oriental peoples should have a nutritional equivalent of meat when they have enough of soybeans to eat with their rice.

Desikachar and his co-workers at the Indian Institute of Science at Bangalore, found the protein of soybean milk to have a value much above that of raw soybeans and which they considered about 90 to 95 percent as high as that of milk. Soybean milk added to a "poor Indian diet" showed good supplementary value.

3. *Potatoes and sweetpotatoes* are not closely interrelated in botanical classification, but appear as a third food group, bracketed together because their general agricultural and dietetic similarity makes them largely interchangeable with each other. Nutritionally there is one important difference: sweetpotatoes are high, and potatoes are low, in vitamin A value.

Henry and Kon, feeding rats with protein at an 8 percent level, found relative nutritive values of 52 for white bread, 76 for Cheddar cheese, and 75 for a mixture of the two foods in which each supplied half of the protein. In similar experiments they found relative values of 71 for potato protein, 89 for milk protein and 86 for a mixture in which each of these foods furnished half of the protein. Thus the

protein of milk, whether eaten as milk powder or as cheese, showed highly significant supplementary value both for bread protein and for potato protein. This new evidence strengthens the basis laid by the experiments of Mary S. Rose and her co-workers showing that the protein of the potato, while small in amount, has high nutritive value in mixed diets. Now that we know so well how to supplement the potato, and that the sweetpotato is itself an excellent supplement to many other foods because of its vitamin A value, we see that this food group could easily and economically be given a larger dietary responsibility than we have been giving it in recent decades.

4. *Green and yellow vegetables* are bracketed as a food group because of their vitamin A values. Of course they have other nutritive values as well. Salad greens are rich in vitamin C and kale and broccoli are so rich in it that, even after cooking, they should still be among the best sources of vitamin C. Logically, sweetpotatoes and apricots belong in this group, and yellow turnips do not because theirs is a different yellow substance. Our per capita consumption of green and yellow vegetables has risen very creditably in recognition of the two facts that they have high vitamin A value and that we are benefited by diets of high vitamin A value even to levels considerably higher than the current Recommended Allowances suggest. For these same reasons our per capita consumption of these foods may well go higher still. It is also to be hoped that increasing amounts of greens, other than those of the Goosefoot family (Chenopodiaceae), will be grown in home gardens and consumed without going to market. Through a wide range of climates and soils, one may harvest kale from his own garden throughout the entire year.

5. *Citrus fruits and tomatoes* are bracketed as a group because the outstanding value that they have in common is a high content of vitamin C. They are not richer in vitamin C than are several other foods but these latter either do not hold their vitamin C values as well or they have some other property which results in their being assigned to another group. Tomatoes are one of the stand-bys of home gardeners and might well be grown and eaten in even

larger amounts per person than they are now or have been in recent years. Oranges and grapefruit, while not so widely grown, now have quite thorough market distribution in the United States and their per capita consumption has increased greatly—and gratifyingly—within the past generation. Barring some calamitous weather condition, they will doubtless continue abundant, for large areas of recently planted citrus orchards are just coming into full bearing. And liberal as is our present consumption compared with the past or with most other countries today, an even higher level of consumption may be still more advantageous. For in addition to the fact that very liberal intakes of vitamin C are now recognized as an asset, oranges and grapefruit are also advantageous in at least three other ways: they stimulate appetite and tend to leave the mouth and alimentary tract in a condition most helpful to digestion; after absorption they help the body to maintain its alkaline reserve; and they are in some way specifically advantageous to the body's use of its calcium supply. One student of nutrition, liking citrus fruits and their juices, impressed with their good effects in building positive health, and knowing that large supplies were in prospect that year, decided to consume as much as he felt like during 12 consecutive months. The total reached 868 pounds, all of which was enjoyed and believed to be beneficial. Much of this was taken in the form of orange and grapefruit juices in the evenings as well as at meals. As one tended to begin and end the days with these fruits or their juices, one was often reminded of the essay on fruits (was it by Milne?) which begins with an encomium on the orange—the Golden Fruit—to which he returns for his peroration, and in which he suggested that some other blossoms be adopted for wedding flowers so that every orange blossom may produce an orange. One wonders what he has left to say of the *Tangelo*, a cross—between the tangerine and the pomelo (grapefruit)—which many regard as the most finely flavored of any fruit. Perhaps the essayist considers this just an especially luscious kind of orange.

6. *Other fruits and vegetables* together make important contributions to the vitamin values and the good general mineral balance

of our dietaries so that even though they are not outstanding year-round sources of any particular nutrient they are yet good investments and might well be given a more prominent place in our dietaries. These other fruits and vegetables also add variety and interest to the dietary and their inclusion—or the inclusion of as many of them and as often as one likes—increases the probability that the total of fruits and vegetables in the food supply will reach the prominence which our present nutritional knowledge indicates to be desirable. Government publications have advised at least seven servings of fruits and vegetables a day. This is an advance which is doubtless an improvement; and in the mind of the present writer there is no doubt that a further advance in the same direction up to from nine to eleven servings of total fruits and vegetables is a still further improvement. If, for instance, a total of ten such servings is planned, of which two are to be of potatoes or sweetpotatoes, one of green or yellow vegetable, and one of citrus fruit or tomato, there will be six servings either of additional portions of some of those just mentioned or of other fruits and vegetables. If the widest convenient variety is desired one could use six different choices on each of the seven days of a week, from among such generally available foods as the following: Apples, of which there are hundreds of varieties; apricots, which have such high vitamin A value as to deserve bracketing with the yellow vegetables; asparagus, a green vegetable at the tip but another vegetable in its bulky stem; avocado (alligator pear, calavo), distinguished from other fruits, except olives, by its high fat content; banana, containing starch which gradually changes to sugar in the ripening process, has about the same vitamin C content as average apples, has like many fruits and vegetables about one part in a million of thiamine, making them collectively an important source when consumed liberally, though the amount in a single small serving may seem negligible. Beans, snap or string; beets; blackberries; blueberries, of which several distinct varieties have been established; boysenberries; cabbage, headed, which has much less vitamin A value than loose-leaf cabbage but about the same vitamin C content; cantaloupe, between tomatoes

and grapefruit in vitamin C content but of less year-round availability in the markets. Cauliflower, lower than cabbage and very much lower than kale in calcium content, but higher than cabbage or lettuce in thiamine and vitamin C content, and not so rich as broccoli, kale, or turnip greens in vitamin C; celery. Cherries, richer than apples, about equal with cantaloupe in calcium content; corn, sweet, similar to apples but below most other fruits and vegetables in calcium content. Cranberries; cucumbers; dates; dewberries; eggplant; endive; escarole; figs; grapes; leeks; lettuce, headed; loganberries; melons; okra; onions; parsnip; peaches; pears; pineapples; plums; prunes; squash, light-fleshed; radishes; raspberries; rhubarb; strawberries; turnips; watermelon; youngberry; zucchini.

7. *Milk and its products other than butter* constitute a food group of great importance. In the United States, and probably in most other countries of the temperate zone, this group is the outstanding dietary source of calcium and riboflavin; and probably those are the two nutrients in which our dietaries most often need enrichment. Also milk furnishes protein of the highest nutrient and supplementary value much more economically than does any other food of animal origin. When an increase of animal protein is wanted milk is usually the most effective and economical answer. And it is at the same time important for its all-round mineral and vitamin values.

No large area yet has as high a level of per capita milk production and consumption as would represent the best use of its food-production resources for the optimal nutrition of all its people. Any serious attempt at optimal nutrition for all will call for both higher production and wiser distribution of milk.

If a person, a family, or a country uses the above seven food groups each up to the full extent that is advantageous, it will follow that the troublesome problems presented by the remaining three food groups will be greatly eased.

8. *Meat, fish, poultry, and eggs* are grouped together essentially as sources of animal protein. From the viewpoint of the present discussion three considerations present themselves at once: (1) The

food group just preceding furnishes animal protein of unexcelled nutritive value in milk and cheese which are almost always less expensive sources than the foods of group 8 and are accompanied by more of the vitamin and mineral nutrients which are important to the good balancing of the diet. (2) Some of the legume proteins, especially those of soybeans and peanuts, rank with the meat proteins in nutritive effectiveness whether considered separately or as supplementary to the proteins of grain products and potatoes. (3) When full use, from the viewpoints of all nutrients, has been made of the foods of groups 1 to 7 inclusive, do not the proteins of those seven groups pretty well cover the protein requirement—or perhaps approach closely to the optimal intake of protein already?

Dr. E. F. Phipard gives the government's best estimate of civilian per capita consumption per day of food energy, protein, and fat from 1910 to 1945, as shown in Table 9.

TABLE 9

CIVILIAN PER CAPITA FOOD SUPPLY IN ENERGY, PROTEIN, AND FAT VALUES PER DAY IN THE UNITED STATES (1910–1945)

Year	*Food Energy in Calories*	*Protein in grams*	*Fat in grams*
1910	3520	99	124
1915	3440	95	126
1920	3350	93	125
1925	3460	93	135
1930	3460	91	134
1935	3170	85	125
1940	3350	93	142
1945	3330	100	137

Thus, according to careful studies of our statistics of food consumption, civilians of the United States are eating half again more protein than is suggested by the certainly generous Recommended Dietary Allowances of the Food and Nutrition Board of the National Research Council. We might be better off physiologically and psychologically if we were to moderate our competition for

foods of the meat-fish-poultry-eggs group and seek rather for a more equitable distribution of these foods between people of higher and of lower incomes both within the nation and between different nations.

9. *Fats,* like proteins and largely for the same reasons, have been consumed by the people of the United States at high levels both in peace and war and even in the depths of the economic depression, as may be seen from the figures for fat alongside those for protein in Table 9. We are accustomed to dietaries rich in both protein and fat. This is the reason that, as already noted, during the war we found no objection on nutritional grounds to the rationing of meats and fats on the same red coupons. For, if one family used all their "red points" for meats, they would probably still get enough fat, and if another family used all theirs for fats, they would doubtless still get enough protein from their other foods.

10. *Sugar* also has been consumed at high levels by the people of the United States. From about 10 pounds per capita per year in 1820, it rose to about 100 pounds per capita per year in the 1920s and has since remained at about that level except for temporary wartime conditions. With sugar as with fat, our high per capita consumption is something to which we have been accustomed for so long that many people would consider it an essential part of our standard of living; while from the point of view of the newer knowledge of nutrition it would probably be better if a part of the calories that we consume in the form of sugar were taken instead in a form such as fruit which would bring into the dietary an advantageous increment of mineral and vitamin values.

Table 10 shows for each food group what percentage of the food money it cost and what percentage of each of the chief nutrients it supplied.

GENERAL RELATION OF NUTRITION TO FOOD MANAGEMENT

Among those dealing with wartime food problems and with plans for a permanent international food and agriculture organization,

TABLE 10

RELATIVE COST AND CONTRIBUTION OF EACH FOOD GROUP IN AVERAGE AMERICAN FAMILY DIETARIES IN 1942.

FOOD GROUP	PERCENTAGE OF TOTAL FOOD COST	PERCENTAGE OF TOTAL CONTRIBUTED BY EACH FOOD GROUP							
		Calories	*Protein*	*Calcium*	*Iron*	*Vitamin A value*	*Thiamine*	*Ribo-flavin*	*Vitamin C*
Grain products [a]	11	30	28	12	21	tr [b]	22	9	0
Dry beans, peas, nuts	1	3	5	3	11	tr	6	3	0
Potatoes, sweetpotatoes	3	5	3	2	7	6	8	4	13
Green and yellow vegetables	5	1	2	5	8	39	6	5	31
Citrus fruits, tomatoes	6	2	1	3	4	7	6	2	35
Other vegetables and fruits	8	4	2	3	6	6	3	5	13
Milk, cheese, ice cream	17	14	23	65	7	15	8	43	6
Meats, fish, poultry, eggs	30	13	33	5	31	16	37	28	1
Butter and other fats	10	19	2	tr	2	11	4	1	0
Sugar, sirup, sweets	3	8	tr	2	3	tr	tr	tr	1

[a] U.S.D.A. assumed 35 percent of bread or flour to be enriched at this time.
[b] tr = trace or less than 0.5 of one percent.
(Note. As original records included food adjuncts which are here omitted, the present columns may not total quite 100.)

the conviction that food management should be guided by nutritional knowledge became so unquestioned a principle that one frequently heard such phrases as "the new science of nutrition and food management." In such expressions, food management means the entire complex of administrative, agricultural, and processing techniques of making the best use of food production and distribution to satisfy nutritional needs, while nutrition means the science that defines these needs and the adequacy of individual foods or diets to meet them.

Nutritional guidance of food management or the unification of nutrition and food management received a great impetus from the intense desire of all the nations at war to give their armed forces and war workers every possible aid to the highest possible efficiency; and the worldwide conviction that nutrition is a powerful aid to such efficiency.

A PERMANENT PRINCIPLE IN A WARTIME PROBLEM

By the middle of 1943 it was becoming apparent, to those having to do with the wartime food problems of the United States, that conversion of corn into meat and eggs had been so attractive financially as to monopolize too much of the corn crop and so cause real shortages of corn for dairy-cattle feeding, and even (for a time, in the South) had interrupted the supply depended upon for direct use as human food.

For these and other reasons, the Government, in its goals for food production for 1944, and the National Research Council advised, among other things: (1) that increased prominence be given in the American dietary to locally grown fruits and vegetables and to the forms of milk that include its nonfat solids; (2) that by virtue of a moderate shift in that direction substantial amounts of foods better fitted for shipment and stockpiling, such as breadstuffs, meats, and fats, can be sent overseas; and (3) that the feeding of grain to meat animals be moderated, so that more grain may be available for milk production while always maintaining safe reserves of grain for use as human food. In wartime discussions of food, one encountered

no substantial difference of view as to the desirability and practicability of such adjustments in the mild degrees in which they were proposed (in the United States), and patriotism helped to make such war measures "work." With the ending of the war, the problem became that of teaching the importance of similar food management for the permanent winning of the peace as well.

In the light of the experience of 1943 and 1944 in handling by scientific management a food situation which would otherwise have become a crisis, it is to be hoped that we may continue to see the importance of guiding our food habits in accordance with nutritional principles.

CULTIVATION OF HELPFUL FOOD HABITS

The principle of the cultivation of food habits that promote equity and goodwill through such economic use of food-production resources as to spread nutritional benefits more widely, belongs at once to the science of nutrition and the science or technique of food management. The far-reaching recent advances of nutritional knowledge which show that food can bring unexpectedly constructive benefit to health and efficiency, the spread of this knowledge both at home and abroad, and the earnestness of many people in seeking to make common cause in this field, have combined to put us in a position of special opportunity and responsibility.

While giving ourselves full benefit of all our nutritional knowledge, we can at the same time so adjust our food habits as to help make these benefits more fully available both to our lower-income fellow citizens and to the less richly endowed among the United Nations.

These nations are uniting because they want a world that permits its various peoples to develop, each in accordance with its own cultural genius, yet all in a world atmosphere or world environment of social justice.

In the field of food this will mean a scientifically honest discrimination between those differences in food habit that are due to cultural choice and those that have been forced by undue economic

disparities, which latter we now wish to ameliorate in a spirit of more equitable distribution of the world's food among the world's people.

For instance, most (though not all) of the other countries with which we have joined to form the United Nations, support from two to six times as many people per 100 acres of comparable land as do we here in the United States. The two chief factors in this difference are that the peoples of the older countries are apt to give more human effort per acre to the care and cultivation of cropland; and that they bring more of the crop directly into human consumption, while we feed much more of it to meat animals.

This we can do because we hold a great deal more than our pro rata share of the world's resources for food production. But also we can see a line of adjustment in food management by which nutritional benefit can be brought both to our own and to other peoples. A few first and clearest steps in this line of improvement have been suggested in the brief discussions of the different food groups as factors in the general food supply. And the same principles should aid the world's present and future endeavors so to use its food-production resources, and so to distribute the food produced, that all people may be well nourished.

It is always to be remembered that to bring the benefits of nutritional knowledge to as many people and as promptly as possible is both an economic and an educational problem. Miss Lucy H. Gillett devotes three of the ten chapters of her book, *Nutrition in Public Health* (1946), to practical problems of getting desirable kinds and amounts of food into the household budgets of those families having low or marginal incomes.

Child feeding problems and the school lunch program were discussed by Dr. E. N. Todhunter at the meeting of the American Association for the Advancement of Science at Chicago in December of 1947. She holds that child health has improved, but not yet in proportion to the increase in knowledge of nutrition. She lists as major causes of poor nutritional status in children: the irregularity and missing of meals, spoiling of appetite by eating between meals,

and such poor food habits as excessive use of soft drinks and candy. In a detailed study of children in three rural schools she found that one seventh of them missed breakfast, and one third missed supper, at least once during a seven-day period for which records were kept. Similar situations have been found in diverse regions so that it is clear that the school lunch is not only a convenience for those children who live too far from school to go home at noon; it must also strive to make good the deficiencies in the meals eaten or missed at home, if children are to have sufficiently good nutritional status to enable them to get the full benefit of their school work. Thus the school lunch offers a very important means of improving the health and fitness of the population of school age. Moreover, when the school lunch is aimed at this higher objective it serves simultaneously the whole of the people through the improved food habits and knowledge of food values which the children carry home to their families, and carry forward in their own mature lives.

Federal aid for school feeding was begun in 1933, partly because of the growing realization that better nutrition was needed in order that the work of the school should be effective, partly as a means of utilizing surplus food, and partly to provide employment. The National School Lunch Act, passed in June, 1946, gave a more permanent basis to governmental aid for school feeding.

As school feeding outgrows its original emergency aspect and becomes a fully recognized and regular part of the work of the school, more clear evidence of its benefit will doubtless be brought to light and permanently recorded.

Todhunter considered that (by December, 1947) measurable improvement in nutritional status of school populations had been demonstrated; even though application of present knowledge of nutrition and food values was far from complete. She therefore suggested the following series of seven goals: That educators and school administrators give increased attention to the importance of nutrition for school children, and increased recognition of the value of the school lunch in nutrition education; that the school lunch be made an integral part of the total school program through

teachers who have sufficient knowledge of nutrition to give children adequate guidance in food selection and the development of desirable food habits; that the school-lunch program be handled by dietetically educated lunch managers, assisted by employees who have been given adequate training for their specific jobs; that children be taught to recognize the school lunchroom as a laboratory for educational experiences; that the school lunch be run on a nonprofit basis, financed like other school services, and that only such foods and beverages as are clearly justified on nutritional grounds be sold at school; that there be further study of methods of nutrition education through the school lunch; and that provision be made for the cooperation of nutritionists, dietitians, public health workers, and health educators (with the classroom teacher) in the program.

CHAPTER IX

The Internal Environment and the Quality of Life

HAVING DEVOTED the preceding seven chapters so predominantly to the assembling of objective facts and to their functioning in immediately tangible principles and practice, it may now be profitable to consider how the new knowledge, revealing, as Sir Walter Fletcher pointed out, so much more than had been foreseen, opens to us a new way of thought through which man can now become more largely the builder of his own life history than science has hitherto considered possible.

This new way lies through the flexibility of that internal environment which before was regarded as fixed. We have seen in Chapter I that, for decades, McCollum had taught that there are or may be important differences between the adequate (in the sense of the merely passable) and the optimal in nutrition. Yet this view seemed to be received with reserve. Similarly we saw that at the same time J. F. Williams taught that health is not simply the absence of disease, but rather it is a positive quality of life which can be built to higher levels. Yet after years of skillful emphasis of this principle, in his direct teaching and through his successful textbooks, he still remarked upon the slowness of anything like general acceptance of the idea of degrees of positive health. When these men were recognized as authorities, why did the principle which they especially emphasized continue so long to be regarded as a matter of opinion, and only so recently become assimilated as settled fact?

The answer is at least twofold. This doctrine which McCollum and Williams, among others, taught each in his own way, and which in a previous chapter we have called the principle of the nutritional improvability of the norm, appears to cut across a way of thought

already firmly established, and also, it seemed to rest on evidence apprehended by the individual expert and not reproduced by many others or in large numbers of controlled cases.

And the doctrines requiring to be substantially modified were strongly entrenched. For at least two generations science had conceived each species to be more rigidly specific in its vital chemistry than it really is, and had believed that the internal environment was too firmly fixed by inheritance to be importantly influenced by the food. But now, in view of the new experimental evidence (cited in previous chapters), the habit of thought hitherto accepted requires substantial revision.

As has happened in connection with some other scientific ideas, a concept which originally was very helpful came to be held too long without re-examination, and so to continue in too rigid a form after discriminating modification was overdue. It was easier to repeat the phrases of great teachers than to do them the higher honor of keeping their teachings up to date by critical re-examination in the light of advancing knowledge. This higher honor we now seek to pay.

In the course of his epoch-making work in the chemistry of agriculture and physiology, Justus von Liebig wrote to the effect that an organism grows and develops only as fast and as far as is consistent with attaining or maintaining the normal chemical composition of its kind. And accordingly it was to be expected that whichever of the growth-essential substances is present in minimum amount or concentration (relative to the needs for growth at a normal rate) becomes the growth-limiting factor. Some of his followers gave this view an undue air of finality and rigidity by tagging it with the title "Liebig's law of the minimum." Liebig himself is not to be blamed for the overenthusiasm of his followers in calling his view a law. Regarded as a guiding concept it was serviceable to the pure scientist to be kept reminded that growth may be limited by even a relative shortage of any growth-essential factor, and that such a retardation or limitation of growth is rather to be expected than that the organism should increase its size at the expense of abnormality

of chemical composition. And to take an illustration from agriculture, Liebig advised farmers to fertilize their fields with phosphates; but only in the expectation that the crops would be larger and not that they would thereby be endowed with any importantly higher concentration of phosphorus.

The same fundamental view which Liebig apprehended in its chemical aspects was emphasized physiologically by Claude Bernard in his oft-quoted aphorism that it is because of the *fixité* of its internal environment that the organism may adapt itself to a new or changing external environment. Its neat form and the fact that it aided so much the explanation both of physiological processes within the body and of the ability of species to spread over the surface of the earth, gave this dictum of Bernard's a wide currency which it is only gradually outgrowing.

As professor of physiology at Harvard, Walter B. Cannon greatly developed by experimental research the fertile field of knowledge which has to do with the ways in which the body maintains its near-constancy of internal environment for which Cannon coined the technical term *homeostasis,* and adopted the nontechnical phrase used in the title of his book *The Wisdom of the Body.*

In the 1939 edition of his book of that title, Cannon took up in turn the characteristics and safeguards of the fluid matrix of the body; thirst and hunger as means of assuring supplies; the homeostasis of the water, salt, sugar, protein, fat, and calcium contents, and the neutrality, of the blood; the maintenance of an adequate oxygen supply; the constancy of body temperature; the aging of homeostatic "mechanisms"; natural defences of the organism; the margin of safety in bodily structure and functions; relations of the nervous systems to homeostasis; the general features of bodily stabilization; and an epilogue on relations of biological and social homeostasis.

Cannon wrote of the word *homeostasis* that it "does not imply something set and immobile, a stagnation. It means a condition—a condition which may vary, but which is relatively constant."

Thus the body's justly celebrated "steady states" are only rela-

tively so, and their flexibility is to our advantage in proportion as we learn by experimental research how nutritionally guided food intake may improve the internal environment or hold it more steadily at its best, with reference to the concentration level of any given nutrient in the body. Unusually discriminating study is called for in this important field.

Cannon cited cases of variable retention of table salt in body tissues; and there are doubtless similar variations of many other substances involved in the nutritional relationships of the internal environment. Thus his chapter on the homeostasis of blood sugar considers 0.10 percent as the normal average and treats variations of 0.07 to 0.17 percent of this sugar as within the normal range, or homeostatic zone. If the familiar things which we regard as held "practically" constant can be so easily shifted 30 percent or more in either direction from the mean, it is clear that variations of diet well within the range of normal food habits may very often have more effect upon our life histories than could have been conceived before the newer knowledge of nutrition had made us aware of the large number of mineral elements and vitamins that play significant roles in our life processes.

Cannon devoted a chapter to aging from the viewpoint of his study of homeostatic "mechanisms." There is a striking consistency of the results of his studies of the effects of age upon the efficiency of the self-regulatory processes in the body with the observations of the relations of diet to the time of appearance of signs of old age in laboratory animals of like heredity on different diets, as reported from the nutrition laboratories of Johns Hopkins and Columbia Universities. Study of Cannon's work gives confirmation and added significance to McCollum's findings that such use of food as the newer knowledge of nutrition teaches—chiefly increased prominence of fruits, vegetables, and milk in the diet—does importantly aid "the conservation of the characteristics of youth." Noteworthy, too, is the confirmation brought by Cannon's chapter on the margin of safety in bodily structure and functions to the findings of nutrition experiments that in respect to some—not all—nutrients the body

may profit by intakes at least two or three times as great as are demonstrably needed to prevent deficiency.

At the end of his chapter on factors of safety in bodily function, Cannon wrote eloquently of the reassurance that it may properly bring to patients (and those in contact with them) to know how much has been done for us by a providence which equips us with "these powers of protection and healing which are ready to work for the bodily welfare." To this we may now well add that our recent advances in the science of nutrition enable us to make these self-regulatory endowments still more effective through such food habits as will keep our internal environment more constantly at or near its best. For it is this internal environment which directly and immediately environs and conditions the processes of our bodily lives.

Cannon explained that the term *homeostasis* seemed better than *equilibria* because the latter had already come to connote the phenomena of relatively simple physicochemical states in closed systems. The distinction he thus made is useful and scientifically discriminating. But it is also true that principles well established by physicochemical research may throw important light on problems of homeostasis. And this may well be of special significance for nutritional problems. Thus when we introduce such active factors as some of the vitamins and mineral salts into our bodily systems, while physiological factors will complicate any attempt to make precise quantitative use of the principles of equilibria, yet we may be confident that before complete homeostasis has been reached, the working of physicochemical principles will have resulted in some shift or shifts of concentration levels or equilibrium points, or both. This must mean that in at least one way the nutritional intake of the active substance has altered the internal environment. In this connection it is important to realize that anything in one's daily food habits which affects the internal environment either favorably or unfavorably, in however slight degree and even if not to an extent that can be demonstrated by any known chemical or other analytical method, may yet influence health and efficiency in the course of a lifetime.

Superficially, it might be thought that no matter how many meal times there may be in a lifetime, the restoration of homeostasis in our open bodily systems will be so quickly accomplished each time as to leave no effect. It is, however, important to recognize the fallacy of the phrase "immediately excreted from the body," especially when the substance thus dismissed is something which leaves not as carbon dioxide through the lungs but as a dissolved solid through the kidneys. On each circuit of the blood around the body, only a fraction of it, perhaps from about one tenth to one seventh, passes through the kidneys, so that, even if these organs were functioning with a clearance efficiency of 100 percent, only about one tenth to one seventh of the waste substance would be removed during a complete circulation of the blood, and during each successive circulation only about that same fraction of what remained would be eliminated, so that the *freeing* of the body from any such waste product or from a superfluous amount of any substance is in fact always far from immediate; it is rather a process of gradual diminution.

Cannon's discussion of Claude Bernard's and J. S. Haldane's views of the internal environment seems to assume that the internal environment in its *mean* condition is optimal for the well-being of the tissues it bathes and so of the body as a whole, but this must be taken as a "first approximation" involving oversimplification. For, in the light of recent studies of the body's responses to experimental variations of the concentration-levels of different essential substances in its internal environment or fluid matrix, it would appear that with some substances such as vitamin C the optimal concentration is above the mean; while with others such as cholesterol, probably the most advantageous concentration is below the mean at least in middle-aged and older people.

Much experimental research will be required before it will be possible to list optimal concentrations of all the substances normally contained in whatever fluid is taken to represent the internal environment. But an extremely important advance has been made in the establishment of the fact that this environment is *not fixed;* that

it can be modified in planned ways, and is influenced for better or worse by each person's decisions as to what foods to eat and how much of each.

The difference between the effects of a minimum-adequate level of nutritional intake which just suffices to meet the directly demonstrable need, and the optimal level which gives the *best* results in the long run, has been found to be so great for *some* nutritional factors as to introduce an essentially new concept of the extent to which the quality of life can be influenced through nutrition.

The so-called Liebig law which predicates constancy of chemical composition for each normal individual of a species, at least at a given stage of its development; and the *fixité* of the body's internal environment as postulated by Claude Bernard, were useful but inexact "first approximations" which now need to be significantly modified in view of the advance of scientific knowledge.

The trend of scientific advance here is somewhat analogous to what has taken place in physics. We can now see that the world in which we live is more flexible than was formerly supposed. Biology, while still calling itself "mechanistic," now says that "the organism is a chemical machine"; and chemical means something more than merely mechanical, and more flexible than a machine is.

The body is more flexible in some aspects of its chemical composition than in others. In some cases this is expressed by speaking of different *thresholds* or of different *rates of clearance*. These terms obviously relate to regulation through elimination. In other cases the regulatory "mechanism" may consist in *deposition* when the concentration in the body fluids and soft tissues rises, and when the concentration falls, *re-solution* may be the result; as, for example, in the case of calcium salts in the bones. Thus the explanation that the body uses the calcium of its bones as a reserve and thus maintains a nearly constant calcium content of the blood, may also be read as an exposition of the fact that the fluctuations of the calcium content of the blood, small as they are, are very real, so real that they are potent to enrich or to deplete the bone. And this potentiality is actually manifested even in response to differences that to descrip-

tive science appear so small as to call for no change in the casual statement that the blood calcium has been maintained at an approximately constant level.

Thus the research work of the present day is very significantly modifying the impression that chemical conditions within the normal body of a given species are practically constant. Moreover, this is clearly a part of the general progress of scientific advance away from the too rigid and too machinelike concepts and analogies of the recent past generations and into a view that is more elastic though based on more rigorously precise investigation. To some readers this may seem to be elaborating the newer idea at unnecessary length. But the older view still colors the habit of thought of a large proportion of educated people, and it is therefore important to emphasize the fact of the change which is now occurring in the newest chemistry and physiology of nutrition.

It seems important to dwell upon this fundamental change of emphasis for two reasons: First because the older, too rigid, too merely machinelike, view of the body and the life-process has been unduly prevalent in the scientific teaching of the past two or three generations (and in much current talk and writing *about* science, even today). And second because the newer view not only improves our philosophic habit of thought but also shows that each of us may himself improve that internal environment which is not so dominated by *fixité* as the past generation thought, but responds significantly to one's daily choices of food and drink. It is this controllable internal environment which actually, directly, immediately environs the life-process from day to day throughout the entire life history.

Let us now turn our attention more toward Liebig's formulation of the same general point of view from which the doctrine of fixity of internal environment was derived. Osborne and Mendel showed that animal growth is suspended when there is shortage of intake of the amino acid lysine. Animals apparently will grow only to the extent that the food permits the body to build a normal proportion of the amino acid lysine into its tissues. But analytical methods for

the measurement of lysine are not yet so developed as to permit one to determine whether or not there is a *slightly* different lysine content of body according to the level of intake. It can only be said that so far as measurable results are concerned, the body appears to stop growing rather than grow up lysine-poor. Yet the body may grow up demonstrably calcium-poor or iron-poor as the result of a marked shortage of calcium or of iron in its food. Also, among cases in which the body receives adequate amounts of all the essential nutrients and grows at the normal rate for its species, different individuals may retain different concentrations, within the normal range, of many of the chemical factors; the level of concentration of the substance in the body depending upon the level of intake. This has been definitely shown to be true of calcium, iron, vitamins A and C, and thiamine by direct experimentation, with determination of their concentration in body tissues or fluids. Undoubtedly it is still more widely true; for observations upon outputs following changes of intake within the normal range show that there is a steady approach to a higher or lower rate of output corresponding to the new level of intake. During the hours or days in which the output is rising or falling to meet the new level of intake there is a plus balance if the intake has been raised, or a minus balance if the intake has been lowered. Hence when approximate equilibrium has been reached at the new level the body actually contains a higher or lower amount of the substance in question. Thus the concentration of the substance in the body is not strictly fixed or constant through normal ranges of intake but is higher when intake is higher and lower when intake is lower.

Furthermore, the differences of concentration in the body corresponding to difference of level of nutritional intake are true not only for substances which are undoubted assets, but also for those which may be liabilities. The latter may be either original factors of intake of which relatively low levels are best, or end products of the metabolism of nutrients. Quantitative studies of "clearance" show plainly that lag in elimination is very real and may be quite measurably different at different levels of intake.

Hence different levels of nutritional intake induce different levels of concentration, either of these nutrients themselves or of their products of chemical change in the body.

The concept of the improvability of the normal bodily status through wiser nutrition is, therefore, not a vague general principle of liberality, but rather a principle of discrimination. Choice of food to increase the intake of some nutritive factors to levels much above those of minimal adequacy is certainly very beneficial, while there are other factors which are essential to our normal nutrition but of which the optimal concentrations are much nearer the minimal-adequate levels.

NUTRIENTS DIFFER AS TO DESIRABLE MARGINS OF INTAKE

For a long time it was confidently stated and sometimes expounded as a principle in economics that one cannot advantageously consume much more food than one demonstrably needs. But recent research has shown clearly that this is far from being equally true for all of the forty or so nutrient factors that the food as a whole must furnish.

Of total food calories it is true that to eat much more than one measurably needs is of no benefit and in the long run is not a satisfaction, as it leads to a burdensome accumulation of body fat.

Of protein, many people enjoy eating a considerable surplus but derive only a passing psychological satisfaction from this "luxus" consumption and probably little if any benefit to well-being.

Yet in long-term animal experiments with vitamin A we encounter a case which is decidedly different. The body is certainly benefited by twice as much, and probably by three or four times as much vitamin A as it demonstrably needs. The higher intakes of vitamin A raise only slightly its concentration levels in blood and muscle, but cause a relatively large increase in the concentration of this vitamin in the liver.

The optimal level of calcium intake as established in large-scale studies with rats in both the Johns Hopkins and the Columbia ex-

periments (the latter covering entire lifetimes and successive generations) is about two to three times as high as the minimal-adequate level which meets the directly demonstrable requirements of normal nutrition. The better balanced the diet in other respects, the less calcium is needed for optimal results. Differently stated, this means that the less well-balanced is the dietary in other respects the more calcium is needed for the best results that the existing handicaps permit.

Thus it appears in our present-day long-time feeding experiments, as it did in S. J. Meltzer's experiments of a generation ago on injections of salt mixtures, that in addition to its specific, always essential, functions in the body, calcium may also serve as a sort of general regulator to protect the body from the strains or stresses which may be thrown upon the internal environment by various dietary imbalances.

The fact that under American conditions of food supply and dietary habits, freely chosen diets may, as already noted, vary greatly in their mineral contents, adds force to McCollum's consistent teaching of the "protective" value of liberal consumption of foods which combine high calcium and vitamin A values.

Numerous experiments with rats, by Drs. H. L. Campbell and L. N. Ellis in the writer's laboratory, have afforded strong evidence that higher levels of intake of riboflavin may distinctly improve the degree of nutritional well-being and resulting long-sustained vitality ("length of useful life") even though the original level of intake was already above that at which characteristic signs of deficiency appear. The two well-established functions of riboflavin in the body—contributing to the defence powers, and combining with protein to form a tissue-respiration enzyme—may both be conceived as attributes of positive health "which can be built to higher levels." These gains over the minimal normal levels of health are doubtless manifestations of superior internal environment. And another is the production of offspring of superior physique and vitality. Riboflavin thus appears to be among the nutrients of which liberal margins of intake are importantly advantageous.

Analogous experiments are being made by Dr. C. G. King with guineapigs, to measure the effects of different levels of intake of vitamin C upon the life history. Here also it appears that the optimal is several fold higher than the minimal-adequate level of intake.

While large surpluses of intake of some nutrients thus appear clearly and conclusively to be beneficial, it should be strongly emphasized that the same should not be assumed to be true of any which have not been explicitly and thoroughly investigated by means of experiments covering whole lifetimes of suitably chosen experimental animals.

It is easily conceivable that saturation of the internal environment with some nutrients may be disadvantageous. Discrimination is extremely important. An undiscriminating openhandedness with all nutrients might be not only wasteful but also in some directions a handicap to the building of the highest health of which the individual is capable.

An extremely important field for further research lies in a combination of microchemical studies of body tissues and body fluids with long-term feeding experiments in which different levels of the nutrient under investigation are fed with a basal diet good in all other respects. New micromethods permit direct study of the human body in parallel with that of laboratory animals. And with these laboratory animals it is feasible to continue the experiments throughout entire lifetimes and successive generations.

Research can thus gradually work out, separately for each nutrient on its own merits, whether we should aim to keep it present in the internal environment at or near the saturation level, or whether it would serve best at lower concentration levels. This knowledge will permit the more discriminating nutritional guidance by use of which we can make our food habits contribute still more to the higher health.

It is probably in part because questions relating to the composition and internal environment of the body lie in a borderline field between biology and chemistry, and in part because of the deservedly great influence of Liebig and of Claude Bernard, that their doc-

trines on this particular point have waited until such a late date for the modifications needed to bring them into consistent relation to points of view which already prevailed in the central fields of both these sciences. Certainly another reason is that feeding experiments of the accurate and comprehensive type best calculated to discover the consequences of differences of internal environment within the normal range are a recent development in research.

That heredity and environment determine the character of the life-process, and thus the life history, has been accepted by all students of science for so long as to be taken as a matter of course. But while formal definitions of environment thus cover all significant factors other than heredity, our actual thinking has tended to treat environment as meaning about the same as surroundings. The general impression that the body is equipped with regulatory "mechanisms" which keep its internal conditions practically constant has so far prevented adequate consideration of the internal environment that when attention is now directed to this, there is often some confusion as to just what is meant, and sometimes even a suspicion of encroachment upon the field of the geneticist when we speak of beneficial effects upon the offspring. Actually, however, the concept of optimal nutrition is separate from anything with which genetics has to do, except that genetic potentiality is realized through nutrition. There is no thought of changing the germ plasm by an improvement of an already normal nutritional condition. There is, however, as we can now see, an important potentiality not heretofore recognized in the improvability of an already normal internal environment through a more scientific selection of what we introduce into the system as food. And this scientific guidance of food habit need not involve the introduction of any new food or the exclusion of any food desired; it may be simply a better adjustment of the relative proportions in which our familiar everyday foods are consumed.

And so far as we can judge from the scientific evidence, it seems probable that the benefits of optimal nutrition can be *added to* all

the hereditary advantages which one may have received in his original chromosomal endowment; and also to such advantages as are received through mental and muscular training, through the sanitation of the surroundings, and through the avoidance of injurious habits and substances.

We are doubtless only at the beginning of investigations designed to answer such questions as, How much difference does it make whether or not the intake of any given nutritional factor is optimal so long as it is passably adequate?

Any such question admits of two constructions: (1) what difference in chemical composition can be shown directly by analysis of the body or some of its tissues of fluids; (2) what consequences can be shown by means of well-controlled feeding experiments on sufficient numbers of laboratory animals, and continued throughout entire life cycles or even through successive generations.

In the second type of method as recently developed, science now has a means of research which it has not possessed before and which promises to reveal greater potentialities than have heretofore been anticipated for the improvement of the already normal life process through the guidance of the newer chemistry of nutrition.

DEVELOPMENT OF THE CONCEPT OF THE NUTRITIONAL IMPROVABILITY OF THE QUALITY OF LIFE

H. J. Waters, a research worker in animal nutrition, wrote in the first decade of our century: "The upper limit of the size of an animal is determined by heredity. The stature to which an animal may actually attain, within this definitely fixed limit, is directly related to the way in which it is nourished during its growing period." This idea that heredity has set "definitely fixed" limits, rigidly circumscribing the possibilities of improvements through increasingly scientific nutrition, was for at least a generation rather too dogmatically taught and accepted.

More recently Todd wrote: "The adult physical pattern is the outcome of growth along lines determined by heredity but enhanced, dwarfed, warped or mutilated in its expression by the influence of

environment in the adventures of life." Nutrition is one of the adventures of life to which Todd referred, and it is now known to be more potent in its influence upon life history than could be fully appreciated at the time Todd wrote. His untimely death was a great loss; for his thinking was expert and lucid over an extraordinarily wide range. Had his life been longer, he would doubtless have made more clear to us his concept of growth as determined by heredity and yet as capable of being "enhanced" by improved nutrition.

Todd's statement clearly suggests a more constructive potentiality for nutrition than did that of Waters. The difference might perhaps be explained in part by the temperaments of the two men, but it also reflects the trend of the evidence.

Thus the objective records of the work of Mendel and Hubbell showed such progressively increased growth through so many generations of their animal colony as could not have been predicted from the heredity of these animals. Increased growth in itself is not conclusive evidence of nutritional improvement, but Mendel and Hubbell here found it to be part of a general picture of enhanced well-being, for the same animals showed also higher adult vitality or stamina as reflected in their success in reproduction and the rearing of young. There seems to be no doubt that there was here a true nutritional improvement of the norm. To call it the mere fulfillment of an inherent capacity, the correction of something that had been thwarting this colony, would seem misleading. Inasmuch as the observed improvement went beyond what science would have predicted, it seems more scientific to call the improvement constructive rather than merely corrective. Of course there is a certain sense in which all improvements can be looked upon as fulfillments of preexisting capacities. But it seems better science to call constructive (and not merely corrective) such improvements as science had not been able to foresee.

Hence Mendel and Hubbell's finding is regarded as a constructive nutritional improvement of the norm, shown by comparison of the experimental animals with their ancestors; and Sherman and Campbell's finding (mentioned in Chapter V) as a similar im-

provement shown by comparison with contemporary controls continued on the ancestral diet.

In the latter study it was also found that increasing the proportion of milk in a nearly minimal-adequate diet resulted in prompter development, higher adult health, and longer life, all in the same individuals. Moreover, the duration of "the prime of life" or of "useful" life was increased in greater proportion than the life cycle itself. In human affairs, this would mean more years of life at full adult capacity and value, with a smaller percentage of years of dependence.

In the animal experiments just mentioned, an already adequate diet was improved by a more scientific adjustment of the quantitative proportions of the natural foods of which it was composed. This better adjustment increased the amounts of certain amino acids, of riboflavin, of calcium, and of vitamin A. Further research using the same method of full-life and successive-generation experimentation has shown that each of the factors just named may play a part in the improvement of an already passably good internal environment and resulting life history. Calcium and vitamin A have both been studied extensively with reference to the effects of stepwise enrichments of the diet in the one chemical factor at a time. In each of these cases large numbers of experiments have shown with statistical conclusiveness that stepwise increase of nutritional intake resulted in correspondingly graded benefits which showed themselves in the life histories of the original experimental animals and in the size and apparent vigor of their offspring.

In Batchelder's experiments with graded feedings of vitamin A it was found that at the higher levels, where the further enrichment of the diet in vitamin A had no further visible effect upon the original animals, there was an appreciable further gain in the degree of positive health of the offspring. On one occasion, when these results were being reported to a group of biologists, a geneticist asked, What is meant by benefit to the offspring? Is there anything that is transmittable through the father? And when assured that the nutritionist was not even considering the possibility of changing the germ plasm through better nutrition, the geneticist asked, Then

has the extra vitamin A done anything more than make the mother a better producer of milk? Clearly, the geneticist's questions are challenges which jump from one extreme to the other. The most probable interpretation is that the benefit conferred by the extra vitamin A did not change the germ plasm but did do more than increase the nutriment conveyed by the mother's milk. Doubtless it also benefited the offspring before their birth—both through the nutriment conveyed, and through the fact that the fetus developed in a superior environment reflecting the betterment of the mother's internal environment by the improvement of her nutritional status even beyond what was observable in her physique.

Experiments with human subjects have also shown that the nutritional improvement of life can and should be begun before birth, for while we do not expect nutrition to change the chromosomes (the germ plasm), it does affect the internal environment which conditions the development of the unborn. Of great interest and importance are the recent and current researches of Stuart, Burke, and their co-workers at the Harvard Medical School.

King summarized these Harvard findings to about the end of 1945 as follows:

(1) The chance of an infant being essentially a perfect specimen and showing robust health was four times greater when the mother's diet had been superior (graded "good" or "excellent").

(2) The risk that the infant would have a low health rating was twenty times greater when the mother's diet had been inferior (graded "poor" or "very poor").

(3) If these Harvard findings applied throughout the country, better nutrition in American homes would mean that well over 1,000,000 American babies each year would start their lives at a higher health level.

Much of such direct human experience can now be correlated with successive-generation experiments with laboratory animals with strikingly consistent and convincing results. In the animal experimentation, the greater success of the mothers in rearing their young, the improved rate and efficiency of growth of the young, the earlier maturity and greater longevity which together result in prolonging

the prime of life in both directions so that old age is deferred in the same individuals in which earlier maturity has been induced—all these are clearly results of improvement in the internal environment.

This makes it clear that between the merely adequate and the optimal in nutrition there lies a broad field for chemical investigation which promises, when cultivated by rigorously quantitative methods, to prove fruitful of results important alike to the understanding of the chemistry of life processes and to their control and improvement.

Here the science of nutrition is both developing and broadening itself and serving the cause of health and longevity.

And by bringing into the feeding experiments as well as the analytical procedures of nutritional research more of objectivity and precision of method, and of the physicochemical point of view, we have outgrown a certain dogmatism and fatalism connected with the previous too static picture of the internal environment, and have freed our minds for further advances in the progressive improvement of the quality of life.

AN EXAMPLE OF THE EVIDENCE OF PRACTICABILITY

A paper entitled "Trends of Dietary Practices of College Women," appearing under the authorship of M. W. Lamb and C. M. McPherson in the January 1948 issue of the *Journal of Home Economics*, shows how a typical group, living in a cooperative house and exercising free choice, responded to the guidance of the newer knowledge of nutrition. Records of their food consumption at intervals from October 1940 to August 1944 showed that they had eaten more than the amounts suggested in a Government food guide of each of the three food groups: (1) green and yellow vegetables, (2) citrus fruits and tomatoes, and (3) milk and its products other than butter. Thus their voluntary daily practice was "above and beyond the call of duty" in this respect; and we need not doubt that they were thereby improving their respective internal environments and qualities of life, while building their positive health to higher levels.

CHAPTER X

Improved Nutrition and Length of Life

HAVING CONSIDERED in Chapters V and IX the general concepts of nutritional improvement and of the quality of life, the length of life is here to be considered in a further setting of some related topics. This chapter therefore deals with trends in our national food supply, with the nutritional status of our people, with the relation of better diet to higher health and longer life, and with the significance of the rapidity of growth.

While the degree of prevalence of malnutrition is still debatable in some respects, there is now clear and ample evidence of the adequacy of our food supply and resources for food production to make possible such adjustments of diet as the new knowledge of nutrition suggests, and of the fact that certain nutrients consumed in higher than hitherto usual amounts may increase the normal adult life expectation by about a decade—and this not added to old age but inserted at the apex of the prime of life. And it is also found that this potential nutritional improvement of longevity is not prejudiced by rapidity of growth as such. The evidence on these and some related topics is summarized below.

TRENDS OF FOOD CONSUMPTION IN THE UNITED STATES

In January 1947 the United States Department of Agriculture issued its Miscellaneous Publication No. 616 entitled *Nutritive Value of the Per Capita Food Supply: 1909–45*. This included tables which served also as the basis for a paper entitled *What We Eat and Why* by Dr. E. F. Phipard in the Department's Yearbook of 1943–47. Data from the original publication are given in Table 11 herewith. For the convenience of the reader the chief groups of

foods are arranged in the same order in which they were in Chapter VIII.

In parallel column with the data of per capita consumption of the different types of food in different years to show the trend from 1909 to 1944 (the latest year for which final figures had been published when this table was compiled) there are given also the corre-

TABLE 11

APPARENT YEARLY PER CAPITA CONSUMPTION OF FOODS FROM EACH MAIN GROUP BY THE UNITED STATES POPULATION AND BY AN INDIVIDUAL ADULT NUTRITIONIST

	POPULATION AVERAGE					AN INDIVIDUAL ADULT NUTRITIONIST
	1909	1929	1935–39	1940	1944[a]	1941–42
Breadstuffs, cereals and other grain products (in lbs.)	309	234	197	192	205	See text
Mature legumes and nuts (in lbs.)	12	16	19	19	20	30
Potatoes and sweetpotatoes (in lbs.)	208	166	143	139	140	See text
Green and yellow vegetables (in lbs.)	77	93	100	103	121	142
Citrus fruits and tomatoes (in lbs.)	44	69	84	95	116	405
Other fruits and vegetables (in lbs.)	211	219	220	226	222	309
Milk and its products other than butter (in qts.)	169	199	205	215	250	360
Eggs (number)	284	324	289	306	337	141
Meats, fish, and poultry (in lbs.)	164	138	137	148	160	49
Fats and oils, including fat cuts and butter (in lbs.)	59	68	64	71	67	See text
Sugar and sweets (in lbs.)	86	113	109	107	106	See text
Cocoa, coffee, and tea (in lbs.)	10	14	16	18	17	No record

[a] Civilian consumption.

sponding amounts consumed by an individual nutritionist during one year 1941–42. Regarding this last column, it should be explained that conditions precluded accurate records of consumption of grain products, of potatoes, of fats and of sugar by the individual nutritionist. Yet the comparison of this individual record with the official governmental estimate for the population as a whole is of interest in several respects. Of mature legumes and nuts, of total fruits and vegetables, and of milk and its products other than butter, the individual ate about 50 percent more than the general population (with the largest difference in the case of citrus fruits). On the other hand, this nutritionist consumed at least 50 percent less than the population average of eggs, of meats including fish and poultry, and undoubtedly of fats and sugar (though the fats and sugar reached this consumer so largely in admixtures, i.e., "made dishes," that their amounts were not determinable with quantitative accuracy). No record was made of the amount of tea, coffee, and cocoa consumed by the individual nutritionist.

Grain products. Here the per capita figures for 1909, 1929, 1935–39, 1940, and 1944 show the well-known decrease from about 300 to about 200 pounds a year. The consumption of grain products by the individual nutritionist was consistent with the general custom but was not determined quantitatively as it was impracticable to estimate the amount of flour used in cookery. Whether the fact that the long downward trend was apparently checked, and succeeded by an increase from 197 to 205 pounds a year was only accidental, or was due to increased confidence in bread as a food as a result of its general enrichment, is not yet clear; but it may become so, with further experience of enrichment.

Mature legumes and nuts. The per capita consumption of these foods by the people of the United States shows a steady upward trend for the past 35 years but the rise has been very slow and the level of consumption remains surprisingly low considering the large nutritive return which these foods offer as compared with their cost. For instance in the Federal food studies of 1942, the average family was found to spend only one percent of its food

money for foods of this group. But the one percent investment brought a return of 3 percent of the calories, 5 percent of the protein, 3 percent of the calcium, 11 percent of the iron, 6 percent of the thiamine, and 3 percent of the riboflavin of the diet. Moreover, much recent research has consistently shown that soybean and peanut proteins are of high nutritive value in themselves and also are very effective as nutritional supplements to the proteins of the cereals.

There is need of fuller appreciation of the familiar beans and peas, and of soybeans and peanuts, which furnish large amounts of protein which is nutritionally much like meat protein, and of the widely varied tree nuts which contribute so greatly to the diversification of the diet.

Potatoes and sweetpotatoes. The combined per capita consumption of potatoes and sweetpotatoes in the United States clearly decreased from about 200 pounds in 1909 to about 140 pounds throughout the decade from 1935 to 1944. This decline of 60 pounds or 30 percent, and the smoothness of the government's per capita figures for the years shown in Table 11, seem much more probably significant than accidental. Just what these facts signify is more difficult to judge. Probably the prevailing view of the people qualified to form an opinion is that the decrease of 60 pounds per person per year in this food group is attributable to the increase of over 100 pounds in the combined consumption of green and yellow vegetables, tomatoes, and citrus fruits (the combined consumption of other vegetables and fruits having remained about the same throughout the 35 years 1909 to 1944). In view of the high vitamin values of the green and yellow vegetables, tomatoes, and citrus fruits, their replacement of a part of the potatoes and sweetpotatoes of our former national diet is doubtless a gain. But it would have been a greater gain if the reduction had been in sugar and vitamin-poor fats rather than in potatoes and sweetpotatoes; for these latter two foods are, when properly handled and managed, rather good sources of vitamin C, and sweetpotatoes have high vitamin A values as well. As we go on from where we now are, we may well

seek to restore our consumption of potatoes and sweetpotatoes to its former level while also increasing our consumption of some of the other vegetables at the same time, and both in partial replacement of foods of little or no mineral or vitamin value.

Green and yellow vegetables. From Table 11 it appears that our national per capita consumption of green and yellow vegetables increased by 44 pounds (or by 57 percent) between 1909 and 1944. This growth was fairly steady and is probably continuing. The rate of consumption of green and yellow vegetables by the individual nutritionist was about 20 percent higher than by the average of people of the United States, and it tended to run higher with more knowledge. Much recent research shows that diets of high vitamin A value promote higher health, an extension of the prime, and longer life. As these facts come to be more widely known and more deeply appreciated, our national consumption of foods of high vitamin A value will doubtless continue to increase. Our farmers could double, treble, or quadruple their production of green and yellow vegetables by use of such a tiny fraction of their land as to have no significant effect upon other crops.

Citrus fruits and tomatoes. Citrus fruits have grown rapidly in use during this generation, as did tomatoes in the generation just previous. Of this combined food group our estimated per capita consumption increased 164 percent during the 35 years from 1909 to 1944. As there is strong indication that citrus fruits will continue to be abundant and cheap, and that tomatoes will continue to be one of the stand-bys of home gardens, the prominence of this food group in our dietaries will probably continue to increase (note the last column of Table 11).

Other fruits and vegetables. Of fruits and vegetables other than those in the preceding four groups, the annual per capita consumption has been remarkably constant for at least 35 years past. Because these fruits and vegetables (while not so outstanding in particular respects as are those of the preceding groups) make worthwhile contributions both nutritionally and in diversification of our diet, it seems probable and in a broad view desirable that our con-

sumption of them will either increase or at least continue to hold its present relative position.

Milk and its products other than butter. Notwithstanding its "melancholy mildness," milk holds a place in our dietary and food supply which will doubtless continue to grow with increasing knowledge and appreciation of nutrition and its significance for health. The level of consumption indicated in the last column of Table 11 is probably no less desirable for people as a whole than for the individual nutritionist whose permanent habit it records. As milk contributes more than all other foods combined, of the dietary calcium of the people of the Western World, it is probable that the 1948 increase in the National Research Council's Recommended Allowance of calcium for adult maintenance may encourage the growing liberality of consumption of milk by American men and women. Undoubtedly this would be an improvement from both the individual and the public points of view. The individual receives in an increased milk supply not only more calcium but also more "first class" protein (which means more of each of several individually essential amino acids) and more riboflavin which ranks with calcium as one of the two nutrients of which our dietaries most often run short. So the individual or family stimulated, in one way (through consideration of calcium) to increase milk consumption, improves the dietary in this way and in three other important ways as well—in the quantities of amino acids, riboflavin, and vitamin A provided. And the nation gains in the use of its food production resources for human welfare because the milk cow far exceeds the meat animals in economy of conversion of animal feed into human food.

Meat, fish, poultry, and eggs. The foods of this group are very strongly entrenched in our traditions, and so long as consumers spend so large a percentage of their food money for them, their purveyors are provided with the means to maintain those of this group in their economically and psychologically dominant position as "main-dish" foods. But some recent government bulletins are showing that intelligent consumers can have excellent meals (as

did the nutritionist of Table 11) with more moderate amounts of meat than most Americans have been accustomed to eat hitherto. Wide disparities of purchasing power and the willingness of many consumers to compete at high prices for large per capita amounts of luxury market grades, tend to put serious strains upon good will and social justice between the "haves" and the "have nots" both within the nation and among the nations. With increasing knowledge of the practicability of better nutrition at less cost, increasing numbers of people may give more open-minded thought to the possibility of some moderation of present competition in the markets for the foods which are inherently expensive of resources to produce.

Fats and sugars. Of fats and sugar which are largely imported, as well as of meats produced mainly in our own country, our American purchasing power has tempted us to become exceptionally large buyers and consumers. With growing knowledge of nutrition, it increasingly appears probable that both physiologically and psychologically, it will be better when the world's meats, fats, and sweets can be more equitably distributed among its people. Each person, being a food consumer, can contribute to this improvement in each day's decisions as to what foods to eat and how much of each.

THE PROBLEM OF THE PREVALENCE OF MALNUTRITION AND THE CONCEPT OF THE DEFICIENCY STATES

"How Prevalent Is Malnutrition?" was the title of an editorial article in the December, 1942, issue of *Nutrition Reviews* (Volume 1, pages 33–34). Surveys of foods consumed by 2,000 families, made by government investigators, were reported to have revealed that over 40 percent of these families failed to receive a "fair" diet and over three fourths failed to receive a "good" diet. And these observations would have given an even more gloomy picture if interpreted by comparison with the Recommended Allowances published by the National Research Council. On the other hand, however, the period of actual observation of each dietary was only a few days, yet every case of intake which appeared deficient as observed over

these few days was treated as habitually so, whereas a short period of low intake probably would very often be compensated within the next few days and so would have yielded no record of deficiency if the period of the food record were longer. Hence the incidence of *dietary* deficiency is high according to the evidence obtained from dietary (food consumption) surveys; while the incidence of *nutritional* deficiency is low as based on official mortality tables with the customary "priorities" in assignment of causes of death, or from the records of hospital admission rates, or from the clinical impressions of physicians in private practice.

Thus the clinical findings of nutritional deficiency usually indicate a lower incidence than would be expected from the frequency of unsatisfactory dietaries. Yet in some cases the difference has been fully bridged by the development of more delicate diagnostic methods with consequent higher findings of incidence.

For example, Dr. H. D. Kruse has, through able and extended research, developed a method of detecting signs of shortage of vitamin A in the body which is so much more delicate than the methods previously used that it makes vitamin A deficiency (*avitaminosis A*) appear much more prevalent than anyone had supposed. And the question has been raised, Does the biomicroscope, which the new method uses, reveal tiny spots or roughnesses which, even if of the kind regarded as symptomatic, are too slight, or too uncertain as to origin, to be wisely regarded as definite signs of disease? Under these conditions we should not be surprised, and need not be disconcerted, if it is felt that Kruse's views on this important question have neither been universally accepted nor convincingly refuted. In recent oral discussions, Kruse has reaffirmed the findings of his 1941 paper which were essentially as follows: Of 143 persons in a low-income group, 45 percent had gross and another 54 percent had microscopic "ocular lesions characteristic of avitaminosis A." Administration of vitamin A resulted in either cure or distinct improvement in all the cases who remained available for sufficient treatment. For detection of early avitaminosis A in surveys, the biomicroscopic examination is recommended by Kruse

as a simple, convenient, objective method. When it is combined with gross examination, all degrees of *xerosis* (the dominant sign) may be graded according to severity and extent. Thus Kruse holds that the marked prevalence of vitamin A deficiency in this low-income group, "validating previous dietary data," suggests its relatively frequent occurrence in the population at large.

Kruse has also emphasized the very long periods of treatment with vitamin A required by his patients for complete recovery; and has suggested that many cases are, in ordinary medical practice, given a mistaken negative diagnosis or case history because the response to vitamin therapy is not sufficiently prompt to satisfy the physician.

Kruse's medical diagnoses and Stiebeling and Phipard's dietary data agree in indicating that a large proportion of Americans do not get as much vitamin A as they should. Later data indicate that improvement has occurred since 1940, and that further improvement by education is still in progress.

Also Kruse has studied the gums by means of the biomicroscope and finds in them a high prevalence of signs of shortage of vitamin C especially among people of low-income groups. The parallelism of the cases of vitamins A and C, notwithstanding that these are such different substances chemically, adds much weight to Kruse's general concept of the deficiency states as published in the *Milbank Memorial Fund Quarterly* (Volume 20, pages 245–61), and the issue for January 1949. He holds that there are differences between acute and chronic manifestations, and that each of these categories may be further subdivided into severe or mild according to the intensity of the pathological process. Hence one should be prepared to meet—and to distinguish—at least four types of deficiency condition resulting from shortage of any given vitamin: severe acute, severe chronic, mild acute, and mild chronic. Again and explicitly, Kruse holds that deficiency conditions which have been developing for a long time must be expected to require a long period—often a year or more—of liberal vitamin treatment for complete recovery. In the past, he presumes, many cases of subacute vitamin deficiency have failed of recognition because of slowness to respond to treat-

ment. Moreover, others, though recognized, have been discharged as soon as the acute symptoms subsided or the level of the vitamin in the blood reached normal, while the chronic condition of affected tissue is only partially cured. Because the concentration level of a vitamin in the blood responds quickly to diet, Kruse holds it to be a rather common occurrence for the blood to indicate a satisfactory condition before the tissue lesion is fully cured. While Kruse's view postulates an even greater prevalence of malnutrition than we had supposed to exist, it has its optimistic side in that it holds much of what has been called senile change to be mild chronic deficiency and therefore reversible by permanent improvement of the diet.

Kruse was chairman—with O. A. Bessey, Norman Jolliffe, J. S. McLester, F. F. Tisdall, and R. M. Wilder as the other members—of a committee appointed by the National Research Council to report upon *Inadequate Diets and Nutritional Deficiencies in the United States.*[1] The outstanding conclusions of this committee were: that inadequate diets and deficiency states are widespread throughout the nation; relatively few cases are of the traditional severe, acute types; most are milder in intensity and gradual in their course; predominantly they are subacute or chronic states: some marked, but very many mild or moderate; there is both a preventive and corrective problem; on the preventive side, production of sufficient food should be maintained, more effective distribution of proper food is needed, and nutrition education should be improved and extended; on the corrective side, there is need for detection and therapeutic treatment of deficiency states among the population; the new diagnostic methods should be disseminated among the medical and public health professions; and finally the committee concluded that nutrition should be more fully taught in the schools of these professions.

The publication of this committee report by the National Research Council, and its wide distribution among physicians, have contributed importantly both to the growing interest in nutrition

[1] Published as National Research Council Bulletin No. 109 (November 1943).

among professional workers in medicine and public health; and to correct the impression of a disparity between the findings of food-consumption surveys and of medical practice, as to the prevalence of malnutrition.

The proportion of unsatisfactory dietaries found by food-consumption studies of typical American families probably remains higher than the incidence of malnutrition found by physicians employing the diagnostic methods and interpretations hitherto used, but not higher than those found by Kruse and his co-workers using the more delicate methods now beginning to be available.

The National Research Council has stated (Bulletin No. 109, page 20) that: "In brief, deficiency diseases have been shown to be widespread in previously unrecognized forms."

And, strictly speaking, overweight is also malnutrition and when so recognized makes the prevalence considerably higher than if only deficiency states are taken into account as in the foregoing discussion.

There remains, however, some skepticism as to whether the nutritional status of the American people is actually as unsatisfactory as the impression one would get from reading the above-mentioned bulletin.

Such skepticism may be based on one or more of three specific doubts: First, whether the records obtained in food-consumption surveys may not fall short of the total amounts of food actually consumed. Second, whether the interpretation of dietary adequacy by comparing these food-consumption data with the National Research Council's Recommended Allowances may not give too pessimistic an estimate of deficiencies for the reason that these Allowances are set at a level higher than the average actual (minimal) needs. And third, whether the extremely delicate new methods, used by some investigators in diagnosing nutritional status, are correspondingly accurate, or may overestimate the number or significance of microscopic signs.

Perhaps the purposes of this book will be served best if we here think not so much in terms of precise medical diagnoses as of the

health of the body as a whole and the building of "whole health" to ever higher levels.

SIGNS MAY BE SIGNIFICANT WITHOUT BEING ENTIRELY SPECIFIC

Dr. Russell M. Wilder, in a paper presented to the meeting of the Association for Research in Nervous and Mental Disease on December 20, 1941,[2] emphasized the fact that the signs of deficiency states as actually seen in people are usually not simple and clear-cut, but rather multiple and not entirely specific. This is because if diets are poor enough to give rise to one deficiency, they rarely if ever are poor in only one nutritive factor. Since 1938, Wilder and his co-workers have been experimenting by inducing isolated deficiencies in volunteer human subjects, and studying their symptoms.

Wilder chose his subjects from among the cured women volunteering from a hospital population of 1,500. "That these women had recovered from mental disorders introduces," Wilder states, "less complication into the interpretation of results than might be supposed." For, as the women were glad to continue to live at the hospital, it was possible to have a long fore period, a long experimental and a long after period in each case, so that each served as her own "control." Two dietetians and three nurses gave full-time service to this research. Many of the subjects developed a pride in the work and a spirit of service. The low-thiamine diet used in the experiment now described contained 450 micrograms of the vitamin daily in the form of ordinary foods, so that it was not so very different from what many people eat, or did eat before the stirring of nutrition consciousness that came with the Second World War. Except for its moderate shortage of thiamine, the diet was good in every way. This low-thiamine period began on July 25, 1940. The lengths of time the different subjects subsisted on the low-thiamine diet without added thiamine were: one case, 93 days; three cases,

[2] The proceedings of this meeting were published as *The Role of Nutritional Deficiency in Nervous and Mental Disease* (Baltimore: The Williams and Wilkins Company, 1943).

132 days; five cases, 169 days; and two cases, 196 days. Loss of appetite was what set the limit to this low-thiamine period in almost every instance. "In all cases, clear evidence of psychologic disturbance appeared before the end of 12 weeks." The chief signs other than lowered concentrations of the vitamin found by analysis were: changes of behavior and of attitude and progressively decreasing ability to do their accustomed work and to make adjustments with each other. "All the subjects became inefficient, irritable, depressed, quarrelsome, uncooperative, and fearful." These traits were not present in the long fore period; after they had developed on the low-thiamine diet they were cured nutritionally without the subjects even knowing that they were being treated.

These results greatly strengthened the probability that low-thiamine dietaries may have played a large part in the prevalence of subacute neurasthenia and related ills, and that the partial restoration of thiamine by the movement for "thiamine-enriched" bread may be helping health even if not visibly influencing vital statistics. The "enrichment" and "restoration" programs have doubtless bettered the nutritional status of the people of the United States.

Wilder emphasizes the facts that the signs were not entirely specific, and yet that they were the results of the same deficient diet, and were cured nutritionally.

The observations of Dr. T. D. Spies, Dr. John Bradley, Dr. Milton Rosenbaum, and Dr. J. R. Knott, reported at the same meeting, indicate on a large scale that anxiety and emotional states such as are often attributed to inherent defects of mentality are largely nutritional in origin, and are curable and preventable by good diet. This finding was also supported by the clinical experience of the several physicians who took part in the discussion reported in the book just cited. And the next chapter in the same book, written by Dr. M. B. Strauss of the Harvard Medical School, points to the prevalence of nutritional polyneuritis, much of which until recently doubtless went unidentified.

These facts are consistent with the emphasis given by Dr. J. S.

McLester to the importance of borderline cases of nutritional failure, and by Dr. Jolliffe to such influence of environmental conditions as he calls *conditioned malnutrition*. Also, in that wartime discussion, the same viewpoint was extended to include something of morale. For Dr. George R. Minot of the Harvard Medical School was quoted as saying that a will to success implies a will to be healthy; and that food be taken to maintain optimal nutrition. Contrariwise, with faulty food, there follows faulty nutrition, faulty function, faulty structure, and finally disease. This series of downward steps from merely faulty food to actual disease may be the result of prolonged use of the same faulty diet, or of an increasing degree of the same dietary fault; as when one allows the "protective" natural foods of the diet to be increasingly displaced by artificially refined foods. Thus according to Dr. Minot, "one should realize that the effect of disease on nutrition and the effect of faulty nutrition on disease may both lead to difficulty."

Another illustration of significance without clear-cut specificity is the relation of nutrition to dental caries.

J. D. Boyd, and his co-workers of the University of Iowa, and independently, T. F. Zucker and his co-workers of Columbia University, have shown clearly that well-balanced good diet including vitamin D milk diminishes very greatly the frequency and the severity of dental caries. W. M. Cox has more recently studied the evidence anew and fully confirms their emphasis upon good nutrition as the outstanding factor in the formation and maintenance of sound teeth.

While there may still be differences of individual opinion as to the precise roles of the different factors, there is no longer room for doubt as to the improvement effected through better nutritional status. An incident from the beginning of Dr. E. C. McBeath's research work is still of interest. The present writer happened to be a member of his advisory committee. At one meeting he told us he thought he had found just the right institution for his researches, but at the next meeting he reported that the general excel-

lence of the school's dietary had resulted in so nearly perfect teeth already that he would have to find a less well nourished group for his experimental studies.

After detailed study of available evidence and commending of further research, the National Research Council's Committee on Diagnosis and Pathology of Nutritional Deficiencies concluded with careful emphasis upon the "real difference" between optimal and "just adequate" nutrition.

Kruse uses the single word *condition* where Jolliffe uses *conditioned malnutrition* as explained above." "A *condition*," Kruse writes, "may be general in nature or scope; its action then is general, not selective and specific." Thus there may frequently be nonspecific ailments or conditions of malaise and inefficiency calling for better diet in a general qualitative sense—a higher proportion of protective food in the diet—not just for one specific nutrient alone. Thus we have the evidence both of single-nutrient experimentation (i.e., with calcium, with vitamin A, with thiamine, and with vitamin C) and of Langstroth's clinical experience with differing proportions of protective foods.

Langstroth obtained long-term dietary records from 501 of his patients and compared these with the clinical conditions which he found. Among people whose habitual dietaries contained only low proportions of protective foods, he found a high incidence of degenerative disease and premature aging. And he obtained strikingly good results when he reformed the dietaries of all such patients in essentially the same way, increasing the proportion of protective foods with reduction of other foods. Relatively little attention was paid to this work, apparently because it was regarded as lacking specificity; but, from the viewpoint of today, it may be regarded as a good example of difficultly classifiable symptomology which was nonetheless significantly related to one type of diet in its cause and to another type of diet in its prevention or cure. From the standpoint of the health and efficiency of the people concerned, we might leave out all medical terms and say simply: "The higher the proportion of protective food in the diet, the lower the proportion

of failures in the preservation (or conservation) of the characteristics of youth." It seems to be excellent evidence for Kruse's general concept.

Nutrition Reviews has referred to "definite changes of personality" as resulting from low-thiamine diet and curable by nutritional means, and has asked: "Would further investigation show that some —certainly not all—of the personality problems of human beings have a basis in unfortunate food habits that prevent the securing of an adequate diet?"

The converse question, whether food habit may also be the effective cause in the development of superior personality traits, seems to be answered definitely in the affirmative by Mann's experiments with English schoolboys. In those experiments, as more fully explained elsewhere, the addition of extra milk, to a diet which had been deemed entirely adequate, induced higher rates of mental and physical growth and the development of superior fitness and spirit.

As summarized in *Nutrition Reviews* (Volume 1, pages 118–119), Kruse's concept is that in a deficiency disease the specific pathological process in a tissue is characterized by velocity, intensity, and sequence. An acute process is rapid in its course and also rapid in responding to therapy. A chronic process is slow in its onset and progress, and in response to therapy. Both the acute and the chronic states may be divided into two or three degrees of severity. The mildest degree is generally of such low intensity as to be recognizable only by microscopic methods. Doubtless a great many people live below the efficiency for which they have hereditary birthright because they have unrecognized chronic nutritional deficiency. Because of the slowness of the chronic cases to react, these people need a permanent adjustment of their food habits into better and fuller accord with the new knowledge of nutrition.

According to *Nutrition Reviews* (Volume 1, pages 72–76), it would seem desirable . . . to apply the term malnutrition only when bodily abnormalities arising from nutritional causes exist. "Malnutrition is not synonymous with deficiency disease. An obese individual is as truly malnourished as an undernourished one. . . .

Although dietary inadequacy is the most common cause of nutritional deficiency disease, there are many others. For example, any bodily condition interfering with digestion, transport, or utilization, promoting destruction or excessive excretion, or raising the requirements of a dietary essential may be a cause."

"An inadequate diet stands in need of correction regardless of what evidence of deficiency disease the physician or biochemist is or is not able to uncover. Our ability to recognize the earliest stages of the deficiency diseases is still markedly underdeveloped. In any event it is hardly sound medical practice to wait until a person has developed a disease before attempting to correct the causative fault in the environment."

TO WHAT EXTENT IS INSTINCT A GUIDE TO GOOD NUTRITION?

Two of the persistent problems in the nutritional improvement of life processes and life histories are: To what extent is the quality of life predestined by heredity, that is, by the individual's inborn endowment as fixed at conception? and, To what extent can instinct be trusted so to guide food habits as to induce and maintain the best nutritional status of which the individual has the inherited or inborn potentiality?

W. F. Dove, working at the Maine Agricultural Experiment Station, developed the concept that these two questions are largely the same, in that one of the advantages which an individual may derive from his inborn constitution is *superior nutritional instinct* such as leads to wiser-than-average choices (qualitative and quantitative) among the foods which the environment affords. Such superiority of instinctive decisions as to which foods to eat and in what relative proportions, results in superior individuals. And they are superior for a combination of two reasons: because of their hereditary endowments; and because of the nutritional environments to which they had access or with which they were provided.

In scientifically guided animal husbandry, the farmer seeks, first, to use for breeding-stock those individual animals which show in-

herent superiority, one factor of which is better-than-average nutritional instinct. And, second, he seeks to make the most of each animal's inborn potentiality by providing enough of the right kinds of food and by such apportioning of the relative amounts of these good kinds of foods as takes account of all available scientific guidance, including the observed nutritional habits of the innately superior individuals of the species. Thus heredity and nutrition are only in part such separate factors as the usual ways of speaking may seem to imply. It is true that we do not expect nutrition to change the genes. Yet it is also true that heredity and nutrition are not wholly independent factors. Rather they are to a large degree the two sides of the same coin with which science seeks to purchase the nutritional improvement of life.

NUTRITIONAL BENEFITS ADDED TO OTHER ADVANTAGES

Is the concept, thus developed largely through the scientific study of animal husbandry, equally valid in human affairs? In one aspect, the answer is a clear and simple, Yes. The benefits obtainable through superior nutrition can undoubtedly be added to whatever of bodily good fortune the individual may have inherited. Beyond this, the working of the principle in human affairs, while perhaps less simple, is no less full of promise. To grasp firmly the potentiality, here offered by the newer knowledge of nutrition, requires that we free our minds from a sort of dogmatic fatalism which tends to make the life process appear more machinelike than it really is.

The newer view is that expressed by Stiebeling: [8] "Food plays an important part in determining the internal environment; and differences in this environment, many of which may be too small to be measured by present methods, definitely affect the plane on which physical and mental functioning go on."

[8] Quoted from page 13 of the National Research Council's Bulletin No. 109. See this same Bulletin for the Committee's argument that much of what is attributed to senility is curable by improvement of diet, and for discussion of the value of lifetime experiments with laboratory animals.

BETTER DIET AND LENGTH OF LIFE

The nutrient factors doubtless differ very importantly in respect to the extent to which surplus of intake over absolute or minimal need is advantageous. To the double question, how much surplus is best and what difference does it make, the usual answer has hitherto been that if the food furnishes enough of any given factor to meet the body's needs, any further intake is practically a matter of indifference. This may be approximately true for most nutrient factors. Of some nutrients, however, there is now convincing evidence that the body can make good use of a much larger surplus. Well controlled experiments have shown that of ascorbic acid (vitamin C), vitamin A, and of calcium, at least twice (and more often three or four times) as much, as suffices for minimal adequacy, is needed for best results even under conditions as favorable as practicable for the nutritional economy; while if special stress of any kind is to be overcome, intakes of from three to ten times the minimal levels for normal conditions may be needed for best results.

Ascorbic acid (vitamin C) has been especially studied by Dr. C. G. King who finds from his own experimentation and from his critical studies of other evidence that, in the case of ascorbic acid, the evidence as to need is chiefly of the following types: (a) intake levels known to protect against the classical and less severe signs and symptoms of scurvy for ages ranging from infancy to full maturity; (b) studies of man and other animals as to amounts of the vitamin needed for satisfactory support of such specific functioning as wound healing, enzyme activity, and resistance to physiological stress; (c) studies of tissue storage at different levels of intake; (d) studies of the quantity supplied to infants by human milk when the mother's intake of vitamin C (and other nutrients) was satisfactory; and (e) comparative nutritional studies of different species. But while these studies result in a consistent comprehensive picture, it still remains difficult to state "precisely what concentration of ascorbic acid in the plasma or blood cells or what excretion level should be considered 'optimal.' The values given in the Table [of

Recommended Allowances] represent a conservative appraisal of all the evidence that is available." Intakes required for actual saturation of the body would be higher than those in the Table.

The fact that different criteria seem to call for such different levels of intake of vitamin C introduces both a troublesome complication and an important opportunity.

Simple prevention of "classical" scurvy was once a satisfactory criterion. Certainly its attainment marked an important nutritional improvement of life as contrasted with an earlier state of affairs in which scurvy was so prevalent as to lead to the serious medical suggestion that practically all diseases might be considered as degrees or modifications or outgrowths of scurvy. But when it was found that prevention of latent and of infantile scurvy could be accomplished by an earlier and more generous use of the same antiscorbutic foods, this higher level obviously suggested itself as a better standard. And then it appeared that still higher levels of intake of vitamin C are conducive to higher degrees of positive health and also tend to give protection against infectious diseases and toxins. To realize the fullest possible protection against these and other special stresses would probably mean keeping the body saturated with vitamin C or nearly so. This saturation level has, however, so often been regarded as an unduly or impracticably high ideal that King recommended and the National Research Council and its Food and Nutrition Board have adopted the Allowances here reproduced in Table 12 (Chapter XII). As these Recommended Allowances are fixed weights whereas the amounts required for "saturation" are subject to the physiological variations of individual people, there can be no fixed formula for relating the two. In general it is believed that "saturation" requires amounts about one third higher than the Recommended Allowances.

Some evidence has been published in support of the view that liberal intakes of vitamin C tend to postponement and amelioration of the aging process (or to "conservation of the characteristics of youth"). If further research supports this view, more people will then doubtless find it practicable so to modify their food habits—

as some of us have already done—that the daily dietaries shall furnish an "insurance" margin of vitamin C above the National Research Council's Recommended Allowance.

Vitamin A was studied by means of extensive and intensive experimentation by Dr. Florence L. MacLeod, Dr. Esther L. Batchelder, Dr. H. Louise Campbell, and others, in the Columbia department of chemistry. They showed that vitamin A is one of the nutrients of which successively increased intakes result in successively improved life histories, up to levels much above those of minimal adequacy. In recent more strictly quantitative experiments, made in the same laboratory with rats from the same colony, Sherman and Trupp have found that, starting from a diet shown adequate by the fact that families are still thriving in the 70th generation upon it, on doubling its content of vitamin A the already normal average length of life was measurably increased, and then, upon doubling the vitamin A again, the length of life was again measurably increased. The total increase in the already normal length of life, by quadrupling the vitamin A value of the food, was 10.4 percent with males and 12.1 percent with females. The length of so-called useful life or prime of life—that part of the life cycle between the attainment of maturity and the onset of old age—was increased in greater ratio than was the complete life cycle. Especially noteworthy is the fact that the optimal level of intake of vitamin A was at least about four times and not more than about eight times the minimal-adequate level which some have been inclined to regard as a standard allowance.

Calcium has also been found, through much experimentation, to be one of the nutrients of which a liberal surplus intake is beneficial. The above mentioned Diet A (Laboratory Diet No. 16), was also the basal and control diet for studying the effects of added food calcium. When the calcium content of the basal diet was about doubled (raised from 0.19 to 0.35 percent) the already normal average length of life was measurably increased in both males and females though less in the females which had borne and suckled an increased number of young. With the calcium content further

raised to 0.64 per cent (about three times the basal level) there were further gains in the life history and length of life. And with a still further increase to 0.8 percent (about four times the basal level) there were again further gains by the females both in their breeding records and in their lengths of life. The gains in length of life were 11.8 percent with males and 13.8 percent with females. The gain of "useful" life was in greater ratio than was that of the whole life cycle.

For the conditions of these experiments the optimal level of calcium intake was three to four times the minimal-adequate level of the basal Diet A. But in another series in which all the diets were liberally well-balanced with respect to their protein, mineral, and vitamin values, a calcium intake twice that of the basal Diet A was found sufficient for best direct results, though higher calcium intakes gave equally good direct results and may have conferred an increased reserve.

Thus it may be concluded that with the diet liberally well-balanced in all respects and all other conditions likewise favorable, it may suffice, for optimal results, to have food calcium at twice the minimal-adequate level, while in less favorable dietary (and perhaps other) conditions, the optimal level for calcium is three to four times the minimal-adequate level. This accords with the view that calcium is needed in conditions of body imbalance for a general regulatory function in addition to the amount required under more favorable conditions.

Protein has been much studied and discussed as to its desirable level of intake in human nutrition. The work of Chittenden discussed early in this book is still outstanding after more than 40 years. And its general purport is well supported by the recent work of Hegsted, Tsongas, Abbott, and Stare [4] of the Harvard school of public health. Normal people can adjust themselves to differences of protein intake so readily and over so wide a range as to make it appear that there can hardly be great significance in the question

[4] See Bibliography under Hegsted, D. M., A. G. Tsongas, D. B. Abbott, and F. J. Stare.

of how much is best. There is general acceptance of current guides without much debate at present because it is the general view that what has been *a* problem of how much protein must soon be recast into a group of problems—the determination of the desirable intake of each of probably eight to ten individual amino acids.

In the organized teaching of nutrition it has been customary to advise that, in planning dietaries for normal people, from 10 to 15 percent of the total calories be given in the form of protein. The National Research Council's Recommended Dietary Allowances formulated in 1940–41 and reaffirmed in 1945 and 1948 show about this same protein-to-energy relation for moderately active people.

Most of the substances now counted as essential to human nutrition still await careful quantitative investigation as to what levels of intake yield best results in the long run of a lifetime.

WHAT SIGNIFICANCE HAS RAPIDITY OF GROWTH?

For a combination of reasons, a considerable proportion of the literature of nutrition has to do with growth. Yet different views are held as to the significance of the rate or rapidity of growth as a criterion of nutritional status and as an index of promise of future well-being. This is because the "promise" of the growth rate [5] depends on several different circumstances.

As between different species, the slower growers are the longer lived, and in general it is expected that an individual will grow during about one fifth of the normal life cycle of his species. Thus a horse may finish his growth in four years and his life in twenty; while his master may have grown for from 14 to 16 years and may hope to live till 70 or 80.

But the scope of the present book extends only to the progress and problems of human nutrition. Insofar as other species are mentioned, it is only for the light they may throw upon human problems.

Pediatricians differ in their attitudes toward rapidity of growth;

[5] The term growth *rate* is sometimes given a more limited and technical meaning, but is here used in the everyday sense, interchangeably with rapidity of growth.

and L. A. Maynard and C. M. McCay of Cornell have described a certain type of experiment in which rats of rapid growth lived less long than those whose growth was retarded. In all such discussions it seems important first to discriminate between the cases in which rapid growth is an individual characteristic and those in which it is induced by nutrient intakes. And, among cases of nutritionally induced differences of growth rate, interpretation should take account of the nature of the background, or basal, or initial, diet.

Does rapidity of growth in itself influence longevity? By careful statistical study of the growth and longevity records of hundreds of laboratory-bred rats whose nutritional and hereditary histories were known and whose care in all respects was alike, Sherman and Campbell found that among individuals of the same sex and the same heredity, on the same normal diet, those growing faster and those growing more slowly have equally good prospects of a long life. Here an objective answer to the question whether rate of growth *in itself* influences length of life has been sought by studying *individual* differences in growth and in length of life among the animals of each of the four groups (each sex on each diet) involved in our comparison of Diets A and B (described in Chapter V). The results show that on comparison of the faster with the slower growing half, or the fastest with the slowest growing quarter, of the individuals of any one of these four "homogeneous" groups, the *individual* variations in rate of growth and length of life are *independent, not interdependent.*

On the other hand, differences in food may influence both the rate of growth and the length of life and may influence them either in the opposite or in the same direction.

Effects of changing rate of growth by diet. In our comparison of Diets A and B (Chapter V), the enrichment of nutritional intake by increasing the proportion of milk in the diet increased both the rate of growth and the length of life; in fact, it has improved the life history throughout.

And in the enrichment of the same basal Diet A by either vita-

min A or calcium alone (without dilution of other nutrients in the diet) increased growth and adult vitality have resulted in the same individuals which then later enjoyed longer life as described earlier in this chapter.

Thus the improvement of life through nutritional guidance of food habit can expedite growth and development, enhance the quality and duration of "the prime," and increase the length of life, all in the same individuals.

But it does not follow that nutritionally accelerated growth can always be taken as a promise of higher health and longer life.

For, starting with the same Columbia basal Diet A used in experiments described above and in Chapter V, the simple addition of protein or of lean meat in sufficient proportion to raise the protein content from about 14 percent to about 25 percent of the dry matter of the food, without change in the proportions of other nutrients, has regularly accelerated growth but with irregular after-effects.

While in a majority of these animals the more rapid growth and earlier puberty is followed by normal breeding records, an appreciable minority of the females (ranging in different series from less than 15 percent to more than 20 percent) have shown an abnormal nervous condition at about the time of puberty and have broken down in or after their first pregnancy or parturition. From many analyses of rats of our colony at different ages we know that at about this age they tend to go through a period of low percentage of body calcium, attributable to the gain of body weight being too rapid for the gain in body calcium to keep pace. The majority "outgrow" this phase without noticeable symptoms; but a minority sufficient to deserve consideration may break down under the added stress of reproduction. Such an unfavorable outcome of protein-accelerated growth may be interpreted as due to a protein-calcium imbalance, or to an undue acceleration of growth, or to a combination of these two stresses. The typical signs have not been observed, and the incidence of such premature deaths has been reduced by better than one half when the enrichment of the diet in protein was ac-

companied by its enrichment in calcium. Certainly we should wish to prevent any such occurrence of protein-calcium imbalance, even if in much lesser degree, in human beings. Present knowledge therefore seems to call for caution in the interpretation of meat-accelerated growth in children as recently reported by P. B. Mack and her co-workers. When liberal amounts of meat are fed to children it would seem to be especially important to insure that their dietaries also contain liberal amounts of calcium.

Thus many factors may enter into the question, "What significance has rapidity of growth?"

At least, however, while recent research has complicated more than it has simplified the answer, yet it serves us well in that it helps to dispel dogmatism or fatalism, and to grasp the fact that nutrition may have a greater range of potentialities than we had supposed.

CHAPTER XI

Further Human Implications

Dr. George R. Minot of the Harvard Medical School has written: "Man's future will depend very largely upon what he decides to eat." And Minot's word "decides" is well chosen. For, in general, the individual conducts his own adventure, of building his future, largely by his present-day decisions as to what foods to eat and how much of each. And the individual decisions of today become the public opinion and the national food habits, and the international food policies, of tomorrow.

To what extent does the nutritional improvement of life imply better mental, as well as physical, health and efficiency? In how far can it mean higher accomplishment and a more satisfying career in whatever field of activity one may choose?

These questions run beyond what nutritional research has yet made clear and certain, but they are amenable to scientific investigation, and present knowledge gives us some light.

Does better nutritional status promise increased efficiency in the work of the brain as well as in that of the muscles? Probably it does, for the level of both muscular and mental efficiency is largely dependent upon the body's internal environment. Here the blood (with the lymph and other fluids derived from it) is the great stabilizing and distributive mediator. And the same blood circulates through all the organs of the body, carrying the fluctuations which dietary differences induce, for better or worse, to the brain and the nerves as truly as to the muscles and the liver.

Probably the new concept of a much more flexible internal environment than science previously visualized, with the new techniques for elucidating human experience by means of laboratory experimentation, will from now on make more objectively convinc-

ing the relationships of nutrition to general stamina or fitness and thus to mental as well as physical efficiency.

WHAT MORE THAN BIOLOGICAL AND ECONOMIC GAINS THROUGH BETTER NUTRITION?

Fitness and *spirit* were the words most emphasized by Dr. H. C. Corry Mann in describing the superior development of the group of boys who received extra milk in his famous experiment, already mentioned in a previous chapter. Some further consideration of that experiment will be much to the point of the present discussion.

Dr. Mann worked under the auspices of the British Medical Research Council, of which the Secretary was Dr. Sir Walter M. Fletcher, a very judicial and research-minded English physician. The work also had the cooperation of Sir Frederick Hopkins, Professor C. J. Martin, and Professor (now Sir) J. C. Drummond.

The experiment was made under exceptionally favorable conditions, and a four months' preliminary period was devoted to testing the administration of the plan. The general setting has been described in Chapter V. All of these boys were English. Each experimental or control group consisted of 30 or more boys aged from seven to eleven years occupying one house and having its own table in the general dining hall. All received as basal diet the regular dietary of the institution.

In House No. 1 a group of these boys, numbering at first 30 and later as many as 55, lived on the basal diet only; while in House No. 2 each boy received, in addition to the basal diet, one pint of extra milk a day. These boys were chosen to match closely the boys in the control group (House No. 1) and the two groups were maintained in strict parallel throughout the experiment. If a vacancy occurred, it was immediately filled with a boy of similar age and weight in order to obtain as many records as possible of boys who had been under observation for one, two, or three years and with complete parallelism especially between Houses 1 and 2. The physical findings have been given in Chapter V. Whenever a boy was weighed and measured he was also examined for any signs of local

or general infection; and observation was kept on the condition of the skin, of the buccal mucous membrane, of teeth and fauces, while at regular intervals a routine inspection was made of the heart and lungs.

Mann reported explicitly that, apart from the markedly greater gains in weight and height, over their controls, by the boys who received the extra pint of milk, there was also a general superiority in their qualitative condition. They were free from chilblains during the winter although these were an almost universal complaint in the control group and other groups in the village who received the basal diet only. Moreover, those boys who had been getting the extra milk for eight months or more showed posture and carriage superior both to the direct controls and to the general boy population of the village. Also, Dr. Mann reported that after eighteen months of the experiment, a visitor entering the dining hall, where the boys of nineteen houses sat at table, "would never fail to recognize the table of that house which was alone receiving the extra ration of milk, the boys of that house being obviously more fit than those of any other house. In addition they became far more high-spirited and irrepressible, being often in trouble on that account." Mann considered that there was (in these experiments) no way of measuring quantitatively this increase of mental activity "yet the change was unmistakable."

The published report of the work has a Preface, signed by the Medical Research Council as a body, in which it is stated that the improved gains in weight and height, which were taken as the measurable characters in this inquiry, were found to be accompanied regularly by improved general health and by improvement in "spirit." They state that the boys who had extra milk were "obviously more fit than those of the other groups." This was the testimony of all those who saw the progress of the experiment. The improved spirit of these boys led to their being more often in trouble for minor offenses against "order." It seems to have been as a consequence of this that their (routine-minded) teachers gave them no

higher scholastic marks. But this fact was held, by the medical men who observed the experiment, to be of little weight as against the general evidence of greater "mental vigour." Mann counted it to the credit of the milk supplement that it promoted a fuller development of high spirits.

Throughout the time of Mann's experiment there was continual study of the basal diet which showed that it was well eaten, that it satisfied the appetites of the boys, and supported normal growth. Yet the addition of extra milk resulted in unquestionable improvement of growth in height and weight, and in general physical condition, spirits, bearing, and fitness—indubitably a nutritional improvement of life which reaches beyond the biological and the economic.

Dr. Fletcher, who followed the work closely and reviewed it with much evidence of keen and discriminating interest in *Nutrition Abstracts and Reviews* five years after the original publication, was very explicit in his statement that the extra milk made an important difference "to the physical and mental growth."

In the Lanarkshire Experiment reported by Leighton and McKinlay in 1930, one half of about 20,000 school children were continued on their usual home diets while the other half received extra milk on each school day for four months. The results as officially reported and interpreted demonstrated that the addition of milk to the diet of children (supplementary to the milk and other food consumed by the children in their regular meals at home) had a "striking effect in improving physique and general health and increasing mental alertness."

Under the authorization and with the aid of the legislation known as the Milk-in-Schools Scheme, the feeding of extra milk to school children was extended to hundreds of thousands of cases, and officially reported as effecting unquestionable improvement in "the children's physical well-being, zest, and mental alertness" and as constituting a "great social and educational advance." (London *Times*, 1941–42, *passim*.)

It is noteworthy that in all of the above-mentioned child-feeding projects, the nutritional improvement was explicitly reported to be mental as well as physical.

But the evidence of the increased mental growth or vigor or intellectual or mental alertness was somewhat less objective than that of increased physical growth. Hence in a special "Milk Nutrition Experiment" made in part to compare raw and pasteurized milk there was also set up a system of quarterly scholastic scorings of the children, all of whom were under observation for a full year. This afforded a numerical record of the relations of the diet to the rate of scholastic progress or improvement of intellectual ability.

In these teachers' assessments of intellectual ability the proportion of children progressing to a higher grade during the year of the experiment was greater among those who had the supplementary milk than among those who did not.

Increased feedings of certain nutrients have also been investigated.

In connection with Macy's extended studies of growth and development in children, it was found that children receiving extra vitamin B [1] made better records than a comparable control group in 59 of the 64 behavior items used by these investigators as criteria of mental development. In the other five test items the records of the two groups were equal.

The experiments of Ruth Harrell, designed to test more specifically the effect of extra thiamine upon efficiency in learning, may be mentioned again at this point. Her first study resulted in better records for the extra-thiamine children in each of the tests used, while in her second study the children who received the extra thiamine scored significantly higher in some of the tests but not in all.

In the work of Robertson, Tatham, Walker, and Weaver less positive results were obtained. They worked with 36 pairs of twins

[1] This was undifferentiated vitamin B but the effects were believed to be more largely due to thiamine than to riboflavin or any other factor.

over a period of 136 days, and then continued the experiment upon 25 of these pairs to a total of 273 days. These children were in their eighth to sixteenth years of age. Each pair ate in its own home and according to its accustomed food habits, except that during the experimental period one child of each pair received 2 mg. per day of extra thiamine, the other receiving an indistinguishable capsule containing milk sugar only. Tests for memory, for speed and accuracy, and for mental dexterity were made at the beginning and repeated every three weeks. Those receiving extra thiamine made greater gains in height and weight and also in manual dexterity and memory retention, but the differences were only on the borderline of statistical significance.

As an advance in scientific thinking, the reform which makes the concept of the I.Q. more flexible, less fatalistic, is analogous to the reform in the concept of the internal environment. For instance, in the case of Mann's findings with boarding-school boys, the superiority developed in those who received an extra ration of milk was manifested in such diverse ways—increased rate of growth in physique, increased resistance to disease, greater alertness, higher spirits and all-round fitness—as to make it probable that the dietary improvement not only influenced the supply of individual nutrients to individual tissues, but also induced a more far-reaching nutritional betterment of the body as a whole, through its internal environment. In the present state of knowledge the strongest scientific probability seems to be that such improvement of internal environment will mean betterment in the functioning of the brain as well as of other bodily organs, with a longer period of life at its prime and a fuller development of mental and physical fitness.

Fitness is usually recognizable, whether measurable or not, and every child should be so fed as to develop and maintain the highest degree of fitness of which he is capable. We now know that food can be a more constructive factor in fitness than was hitherto conceived. In 1922, B. T. Baldwin wrote that a relation between height and mental age appears even when the influence of chronological age is eliminated. Later, a group of 594 California children "with

exceptionally high I.Q.s," were found to average above all available comparable groups in both height and weight.

Other investigations have shown similar correlation. Whether there is any strictly causal relationship between the higher physical measurements and the higher I.Q. grades is not certain. But scientific probability favors the view that a diet which affects favorably the growth and fitness, as in Mann's study of boys, is at the same time inducing an increased capacity for mental accomplishment.

MENTAL ACCOMPLISHMENT

Admittedly some of the attempts to measure mental growth have been less objective than are the measurements of physical growth.

It is, however, very noteworthy that if all the attempts to measure mental growth or intellectual ability were disregarded we should still have excellent scientific ground for the expectation of superior intellectual careers in those persons whose lifetime food habits have been such as the newer knowledge of nutrition teaches. For, this new knowledge offers us more years at our best, and clearly this in itself would mean more opportunity for mental development, attainment, and accomplishment.

There is much reason to suppose, and little if any reason to doubt, that improvement of the body's internal environment, brought about through nutritional guidance of food habits, enhances mental fitness, even if not as obviously as it does physical fitness. It is reasonable to believe that conscious chemical control of the internal environment through our decisions which foods to eat and how much of each, is fundamentally good conditioning of the whole body including the brain; and contributes to the good functioning of the brain as the tool through which the human spirit works.

The good accord of well-established physicochemical principles with the evidence yielded by the new order of laboratory feeding experiments extending through entire lifetimes and successive generations of large numbers of animals of appropriate species, means that there is no scientific doubt of the reality of the chemical control of the body's internal environment by food.

Very likely there may be a considerable period of debate as to which mental traits (or qualities) are most open to improvement through more scientific nutrition, and which are in greater degree fixed by inheritance. Both inheritance and nutrition doubtless influence alertness, and it is scientific to suppose that they both may also influence other aspects of mentality. It is also easily conceivable that when a psychological examination includes a number of different mental tests, some of these may be more influenced by inheritance while others are more influenced by environmental factors including nutrition.

Thus recent and current developments in the concepts and methods of research are now enabling nutrition to make increasingly helpful contact with psychology in the study of the influence of food upon mental efficiency; as also with genetics in the study of constitutional stamina.

Evidence multiplies in support of Sir Frederick Hopkins' well-considered statement that "Nurture can assist Nature" to a greater extent than science has hitherto thought.

And so far as we know, this assistance from scientific nutrition can be added to whatever constitutional endowment may have come through inheritance, as well as to those abilities acquired through sanitation of environment and through training of body and mind.

Moreover, through the constructive potentialities of today's knowledge of nutrition, maternity can be and is being made the occasion of building higher health both in the mother and prenatally in the infant too, so that the latter's "inborn" assets include, with the inherited, also the "more" that has been added through the superior nutritional status which has been induced in the mother by the good diet during her pregnancy.

NUTRITIONAL IMPROVEMENT OF MATERNITY

Burke, Beal, Kirkwood, and Stuart, of the Harvard Medical School, published in 1943 the results of a long study of the effects of the diet during pregnancy upon the mother's health and upon

the development and vigor of the infant. We here condense the account which appeared in *Nutrition Reviews*, November 1943.

The women were patients in the prenatal clinics of the Boston Lying-in Hospital and had frequent examinations, including dietary analyses. Diets were called optimal if they provided daily: 2600 to 2800 Calories, 85 to 100 g. protein, 1.5 g. calcium, 2.0 g. phosphorus, 20 mg. iron, 8000 I.U. vitamin A value, 2.0 mg. thiamine, 2.5 mg. riboflavin, 18 mg. niacin, 100 mg. ascorbic acid, and 400 to 800 I.U. vitamin D. A rating of "excellent" was given to those diets which contained these "optimal" nutritive values, "good" if they had 80 percent, "fair" if they had between 60 and 80 percent, "poor" if they had less than 60 percent, and "very poor" if they had less than 50 percent. The findings reported are for 216 women and their infants. The course of the pregnancy was found related to the adequacy of the maternal diet. Of the women with "good" or "excellent" diets, 68 percent had a normal course; while of the women with "poor" or "very poor" diets only 42 percent had a normal course. The women on better diets had easier labor, even though their babies were larger. The condition of the babies at birth ran strikingly parallel to the adequacy of the mothers' diets. The "superior" infants were produced by the mothers on the "good" or "excellent" diets; the "poor" infants were predominantly produced by the mothers whose diets had been rated poor.

NOURISHMENT AND THE HUMAN SPIRIT

What may fairly be called clinical experience—not entirely objective, perhaps, and yet having significance worthy of careful consideration—gives us at least suggestive evidence that our food habits, acting through modification of our internal environments and their influence upon our brains, may play a larger part in our more-than-biological lives than we are yet accustomed to think.

It is also conceivable that such influence may reach beyond the merely material efficiency of the brain, into improvement of the spiritual self.

The unanimous opinion of the British Medical Research Council

that the boys who received the extra milk in Mann's experiment showed a gain in something which they called "spirit" is worthy both of thought and of further experimental investigation. Of the supplementary foods fed by Mann the one second in effectiveness to milk was watercress. It is easily conceivable that the supplementation of the basal diet by both milk and watercress might have contributed further to the more-than-biological benefit which Mann and the members of the British Medical Research Council called an improvement in spirit. And it is also conceivable that the additional benefit of a still more liberal consumption of fruits and vegetables as well as of milk might become more important with time.

One may try, for and with oneself, the effect of living more largely upon fruits, vegetables, and milk than present-day teaching commonly suggests. Nearly all current recommendations represent only a first step in the guidance of daily food habits by the newest knowledge of nutrition. For, nearly all current recommendations are still in some degree tradition-bound. Those who write them hesitate to advocate more than a slight adjustment of food habits in the direction indicated by our nutritional knowledge.

But, as has already been said, nutrition is everyone's adventure. Any reader of these pages who desires to be scientifically progressive instead of tradition-bound in garnering the benefits offered by the nutritional knowledge of today may go much farther than most writers yet (1949) suggest in living more largely on fruits, vegetables, and milk. Our present knowledge justifies a high degree of confidence that this will be beneficial in the broadest sense, even if it involves retrenchment of expenditure in some other directions.

VALUES OF THE EXTRA YEARS

Both clinical studies of direct human experience of the influence of food habits upon the onset of aging, and controlled experimentation extending through entire lifetimes and successive generations of laboratory animals, show that the nutritional extension of the adult life cycle means not a longer period of senility but a longer period of the prime.

The extent to which the prime of life can logically be expected to be extended by nutritionally guided food habits is greater the earlier in life this nutritional guidance begins.

Results of research previously cited have shown that the nutritional improvement of life can begin before birth and can continue throughout the life cycle. And such scientific guidance can also mean postponement of the aging process in the same individuals in whom the attainment of full development has been expedited, by wise nutritional guidance of food habit.

Moreover, in accordance with the fact that the nutritionally improved life is longer because it has been lived on a higher health plane with lower deathrates at all stages of the life cycle, the period of the prime in the life history thus improved will be not only longer but also on a higher level of attainment and efficiency than presumably would be reached at any age by the same individual living otherwise similarly but without the benefit of the guidance of today's knowledge of nutrition.

Two qualifying possibilities should be mentioned: Undue concentration of growth-stimulating factors in the diet may result in a "forced growth"; that is, a growth rate in excess of that which lays the best foundation for the life history as a whole. There is also the more remote possibility that a rare individual may have such inborn superiority of nutritional instinct as not to need the conscious guidance of nutritional knowledge in order to build himself an optimal life history. Granting that conceivably there may be a few people whose innate endowments include a nutritional genius of this kind, there appears to be a stronger probability that a wise use of today's knowledge of nutrition will add both to the height and to the duration of the careers of most individuals whatever their inborn endowments and constitutions may be.

Higher health and longer life, whether due to inborn constitution or built by the individual through nutritional improvement of life processes, or both, can importantly implement life's ambitions and ideals whatever these are.

No longer need it be so generally true as once it appeared to be,

that life after 70 is but burden and sorrow. Time is a large factor in the building of satisfying and serviceable lives. When men whom the rest of us would like to resemble in the building of life histories have lived well beyond 70, we usually need not even know them intimately in order to see that the years beyond 70 have added much both to the satisfactions enjoyed by the individual and to the value of his total service to others. The reader is invited to study this view by the case method. As starting points, one might consider the varied careers of such different men as:

Nicholas Murray Butler, a builder of civilization to the end of his life at the age of 85.

Walter B. Cannon, active in scientific research and writing to the end of his life at the age of 76.

Charles Phillips Cooper, hailed by the New York *Times* as still active in the improvement of journalistic standards, at the age of 82.

Edwin Grant Conklin, active in scientific organizations and publications at the age of 85.

Wilbur L. Cross, outstanding teacher, dean, editor, and governor —a strong influence up to the time of his death at 88.

John Dewey, still writing influentially at 90.

Charles W. Eliot, regarded by many as our leading citizen, and serving the public in many ways, till after the age of 90.

Charles Evans Hughes, Chief Justice of the Supreme Court till the age of 79, and active in promoting good relations between the followers of different religious faiths up to the end of his life at 86.

Cordell Hull, Secretary of State between the ages of 62 and 74, still an outstandingly influential writer on national affairs at 78.

William Ralph Inge, who (though retired from his deanship, probably at the height of his powers at 74) is still an influential religious writer and anthologist at 89.

Rufus Matthew Jones, who continued his outstanding religious work till within two months of his death at the age of 85.

Charles K. Ober, long the "Master Recruiter" and regional secretary

of the Y.M.C.A. and a continuing spiritual influence at the time of his death at the age of 92.

Henry Lewis Stimson, who served as Secretary of War from the age of 73 to that of 78, essentially responsible for the chief policy decisions regarding the use of atomic energy in 1945; public adviser through writings and interviews at and after the age of 80.

Alfred North Whitehead, outstandingly eminent and influential philosopher to the end of his life at the age of 86.

Owen D. Young, outstandingly active and influential citizen at 75 (and, we hope, for many years after).

The longer lease of healthier and more efficient life which the newer knowledge of nutrition offers should enable a steadily increasing proportion of people to build themselves life histories of comparable attainment, satisfaction, and service.

With more buoyant health and with good prospect of more time at one's best, it should not be unduly difficult to make life less hurried, less self-centered, less contentious: more genial, thoughtful, and spiritual, with fuller opportunity for the passing on of the torch of ever higher human aspiration from generation to generation.

Overstreet's *The Mature Mind* will have accentuated the interest of many of its readers in so using our resources for living as to extend our prime of life.

NUTRITION AND FOOD MANAGEMENT IN A CIVILIZATION ON TRIAL

Obviously this section is largely inspired by Toynbee. His view, that civilizations either weaken and decay or become stronger and progress according to the degrees of intelligence and earnestness with which they meet the challenges that life on our planet brings, carries heavy implications of the significance of our use of food. For, we are living in the midst of a worldwide challenge in that the number of people on the earth appears to many to be increasing more rapidly than the number of available and unspoiled acres on which to produce the foods and fibers we consume. Each consumer of foods,

is (whether consciously or not) responding or failing to respond to this challenge, and is thus helping or hindering the progress and survival of our civilization. For, inevitably, our choice and use of each food commodity will either help or hinder the adjustments which must be made if the crops produced on the earth are to support the improvement of life to which science shows the way.

In addition to all that can be done in other ways there is much to be done to meet this challenge through acceptance of the guidance of the newer knowledge of nutrition in our daily use of food. Thus in preceding chapters we sought to explain both the benefit which the science of nutrition now offers to the individual reader, and how this may be had through such choices of food as tend to spread the same or some related benefit to other people. This means making full use of direct-food crops such as grains, vegetables, and fruits in which "original calories" come directly into human nutrition; and reducing our consumer demand for foods which like grain-fed meats are inherently expensive of resources to produce. It also means enhancement of social justice with consequent strengthening and progress of our civilization.

Even as this is being written the New York *Times* reports an arrangement by which the United States is to send a large amount of wheat to India, to be paid for with manganese and mica.

WHAT NEXT IN THE SCIENCE OF NUTRITION AND FOOD MANAGEMENT?

Nutrition, even more than other sciences, appeals both to our spirit of wonder and to our spirit of service. It has accomplished more than was foreseen, and yet it is still an actively developing science from both of these points of view.

From the viewpoint of understanding, the nutrition research of recent years has discovered many previously unknown substances, the behavior and functions of which in our bodies are subjects of outstanding scientific curiosity. And this spirit of enquiry has been greatly accentuated by the establishment of scientific principles which can have a most important liberating effect upon our thinking. As we now know that the internal environments of our body

tissues and fluids are not so fixed as was hitherto supposed, but can be importantly improved by the more scientific use of food, we see that this can also result in better and longer life histories. With this new knowledge we can be not only policemen and repairmen of our life cycles but also *architects of the higher health*. Whether the human implication of higher health and resultant longer life be conceived as offering us an added decade or more or less, the extra years are always to be conceived as inserted at the apex of the prime of the life which is guided by the newest knowledge of nutrition.

And there is doubtless still much more to be added to our new-found abilities to build our own life histories.

We have seen that optimal addition of calcium or of vitamin A increased the already normal longevity of our experimental animals by from 10.1 to 13.8 percent; but what the effect will be of making both these optimal additions at the same time remains to be determined by further experimental research.

Similar quantitative studies remain to be made with other nutrients separately and in various combinations. Such studies with human subjects should be made to cover as long a segment of the life cycle as is practicable. And with properly chosen experimental animals nutrition research workers can determine scientifically sound human implications for entire life histories. Without expecting better nutrition to change the species we may confidently expect that it will bring to a much larger proportion of people such superior life histories as now are enjoyed by only the most fortunate few.

And our human implications may include the expectation that, as we come to fuller realization of the gains in well-being which we now know how to make through nutrition, we shall seek an ever wider distribution of these benefits.

CHAPTER XII

Better Nutritional Status for More People

NUTRITIONAL STATUS is the term now chiefly used (with "nutriture" as an alternative term) to denote all aspects of the body's condition of nutrition. The newer knowledge of nutrition has seemed to call for some such new term because the simple phrase, "condition of nutrition," had been and still is so commonly used to connote merely the degree of fatness or the relation of weight to height. This latter is, however, essentially a matter of the energy aspect, whereas there are as many other aspects or requirements as there are essential factors in our nutrition.

The title of this chapter implies a possibility of betterment of nutritional status in the people of our present or near-future population. It is true that some recent writers have voiced extreme pessimism over the prospect of an increasing population at the same time (they fear) with decreasing productivity of soil. But those who seem to be the best judges take a more optimistic view.

Both plowed and pastured lands can be made more productive; and man can get more of his food from the sea, certainly, and possibly from some of the water cultures now under experimentation. Certainly, too, food supplies can be used more efficiently.

In 1945 the United Nations Interim Commission on Food and Agriculture Organization (FAO) reported in the publication entitled "The Work of FAO" that the idea of improvement of life through better food supplies and their more scientific use has spread and become "one of the convictions most characteristic of the thinking . . . of this generation, . . . [a view] held by hard-headed businessmen and skeptical scientists no less than by dreamers and idealists." In the view of FAO, "This generation goes beyond the conviction that freedom from want can be achieved, and believes that the effort to achieve it has become imperative. . . . It

will be the business of FAO to seek . . . for progress toward freedom from want and higher levels of living for all. . . . Knowledge about better production methods, better processing and distribution, and better use of foods is available. . . . How to get it put into practice on the necessary scale is the problem. Even in the most highly developed countries, where . . . the general level of nutrition is relatively high . . . as many as a third of the population fails to reach the level of health that good nutrition would make possible." . . . And "in the opinion of experts in nutrition . . . it is possible even in poor areas and at existing economic levels to bring about a fairly rapid improvement in the health of immense numbers of people by using present food supplies (and food-production resources) to better advantage."

The practicability of such redirection of agriculture as to take fuller account of present knowledge of nutrition has been discussed by F. F. Elliott;[1] and the adequacy of the earth to feed its people, by R. M. Salter,[2] by C. E. Kellogg,[3] by M. K. Bennett,[4] and by E. J. Russell while S. E. Johnson has dealt[5] with such immediate measures of farm management as may be involved.

Salter's paper is a good example of the realistic and objective approach to the question whether the world's soils can grow the crops that would be needed to furnish all its people with diets nutritionally adequate according to present scientific knowledge of the body's need for full health and efficiency. As a definition of such adequacy he uses the tentative conclusion of the *World Food Survey* made by the Food and Agriculture Organization of the United Nations in 1946. This aims not simply at restoration of prewar nutritional levels but at food supplies of such kinds and proportions as to meet present-day concepts of diets adequate to support good nutritional status, and for the increased numbers of people to be

[1] *Journal of Farm Economics*, 26 (1944), 10–30.
[2] *Science*, 105 (1947), 533–38.
[3] *Farm Policy Forum*, 2 (1949), 1–5.
[4] *The Scientific Monthly*, 68 (1949), 17–26.
[5] *Changes in Farming in War and Peace*, U.S. Dept. Agriculture, Bur. Agr. Econ., F.M. 58, June 1946.

fed over the prewar populations. According to this estimate, made and published by FAO, there would be needed the following increases beyond prewar production: cereals, 21 percent; roots and tubers, 27 percent; sugar, 12 percent; fats and oils, 34 percent; pulses and nuts, 80 percent; fruits and vegetables, 163 percent; meat, 46 percent; and milk, 100 percent. Salter views the two main courses obviously open for us to follow according to present knowledge as: first, more intensive and more efficient use of the land now farmed; and second, expansion of farming in areas having undeveloped soil resources.

Salter then reviews what was done during the war, and what could be done with known methods applied to known resources for food production, writing from the viewpoint of his well recognized good judgment and of his expert knowledge as Chief of the Bureau of Plant Industry, Soils, and Agricultural Engineering of the United States Department of Agriculture. He cites the fact that, during the Second World War, American production of food crops was maintained at about 35 percent above that of the period from 1935 to 1939; and that, while the weather was more favorable during the war period, "even with no more favorable weather the production would have been 20 percent greater (than prewar), despite the fact that the (agricultural) labor force was actually 6 percent smaller." He finds that the limiting factors in food production "seem to be lack of education and lack of capital rather than any limits of physical production capacity." And he cites recent experiments which show that under ordinary farm conditions the yields of corn in the Southeast can be more than doubled by a combination of improved practices. Salter writes that there are even greater possibilities, though perhaps more difficulties, in increasing food production by bringing new lands into cultivation. "At present only 7 to 10 percent of the total world land area is cultivated," although 52 percent of it could be. Obviously the soils offering greatest natural advantages have been brought under cultivation first, but food-producing areas can be (and are beginning to be) greatly extended by "reclamation of alluvial soils, either by drainage or irrigation, or both." As a

matter of fact only a relatively small fraction of the available (but unused) land would need to be brought into food production in order to meet the goals suggested by the Food and Agriculture Organization.

As the result of his careful studies, Salter reports himself "convinced that we do have the soils we need, we do have the fertilizer resources, we have available the management ability, and we could produce enough food for all."

Kellogg entitled his paper, "The Earth Can Feed Her People," while Bennett wrote under the title, "Population and Food Supply: the Current Scare." Kellogg, who is Chief of the Division of Soil Survey, United States Department of Agriculture, estimates that, putting together only a small fraction of the available new land and the increase demonstrated possible on the land now being farmed, "would give us food significantly beyond that needed for the estimated world population of 1960." And Bennett, who is one of the scientific Directors of the Food Research Institute at Stanford University, also writes of food prospects in reassuring terms. Incidentally he mentions 150,000,000 acres in Brazil as suited to the growing of wheat but not yet employed.

While all nutrition-conscious people may well join other forward-looking citizens in working for a more comprehensive and vigorous campaign of soil conservation, there is no such danger of failure of food supply as to detract from the hopefulness of our effort in behalf of better nutrition for more people. Nor need we postpone our individual efforts as daily consumers of food. For it is literally true that the food we consume and demand as consumers will influence both our individual planes of positive health and the market demand which supports the production of a nutritionally superior food supply for the public, with resulting enhancement of public health through improvement of the nutritional status of an ever-increasing proportion of our people.

Since the above was written, Sir John Russell's discussion of the problem of providing food for the world's growing population has appeared under the title, "The Way Out," in *Science News Letter*

for April 2, 1949. Russell accepts the estimate that the present world population is about 2,200,000,000 and that it is increasing about 20,000,000 a year. The total land area he gives as about 36,000,000,000 acres; but emphasizes that all estimates of the cultivated or of the practically cultivable area are very uncertain. Perhaps only about 4 to 10 percent is such as a prosperous farmer would choose for cultivation but a much larger area can contribute now as grassland, and can be brought under cultivation sooner or later according to economic conditions. "Arable land produces more food per acre; grassland produces it more cheaply" is Russell's diagnosis of the discrepant estimates. Russell states that, in Europe, countries with less than about one and one half acres per head of arable and tended grassland have to import food; while those with more, usually produce a surplus for export. However, he recognizes considerable variations within Europe in the productivity of the land and the standard of living of the people. Russell holds that it will not be easy but it will be practicable to raise adequate food for all by increasing the productivity of the land, and by bringing more land into use. These gains can be made both with arable and with pasture land.

On the drier parts of the earth, irrigation can be, and is being, greatly extended.

Cold-resistant crops are being bred to make fuller use of low-temperature regions, and tropical jungles are being cleared for crop production. Russell also writes that peasant farming undoubtedly can be transformed into more highly productive systems capable of producing more food of highly nutritive value, and of increasing the output both per man and per acre. We may and should anticipate also a further shifting of emphasis in the farm animal population from meat animals to the milk cows which yield so much more to human nutrition in return for their pasturage and for whatever of field crops may be fed to them.

The earnestness with which many economists have taken up the movement for better nutrition is impressive. Thus in 1948 J. D. Black and M. E. Kiefer wrote, in the introduction to their *Future*

Food and Agriculture Policy that their book "undertakes to combine these two important interests, the well-being of farming folk and the better nutrition of mankind, and outlines methods and procedures in both the national and international spheres of action that will achieve these two objects together."

As illustrating the possibilities of fuller use of land, Black and Kiefer state that if the land of the United States were in Europe, probably twice as many of its acres would be cropped (in some way) than are being cropped now.

With the continuing growth of nutrition consciousness it is reasonable to anticipate that the bringing of more land into cultivation will not always be limited according to expectation of money profits; but may increasingly embrace areas which are financially only marginal but which can serve the public health and well-being through betterment of the national or of the community food supply. For a nutritionally good food supply is now increasingly recognized as a matter of public concern, as is a good water supply.

As the practicability of the building of higher health through superior nutrition is more broadly and clearly understood, money can be made available for the extension of nutritionally guided food production on the same principle as for extension of water supplies. With good distribution, the extra food produced can not only support a growing population but also make possible a general improvement of nutritional status or, as the National Planning Association has aptly put it, can build better human beings "which is the principal object of civilization."

HOW MUCH FOOD FOR BEST NUTRITION?

The National Research Council's *Recommended Dietary Allowances* are generally regarded as the best present guide to desirable levels of nutrient intakes. These recommendations are summarized in a table, often called "the yardstick of good nutrition," which suggests a quantitative allowance of each of ten nutrient factors for each of seventeen categories of people. These recommendations are here reproduced in Table 12 with its official footnotes.

As explained by the National Research Council, "The term 'Recommended Allowances' rather than 'Standards' was adopted . . . to avoid any implication of finality or of minimal or optimal requirements." And, "the recommendations are not called 'requirements' because they are intended to represent not merely the literal (minimal) requirements of average individuals, but levels enough higher to cover substantially all individual variations in the requirements of normal people."

The National Research Council further states that there is evidence from long-term (animal) experimentation that one may, in the course of a lifetime, derive increased benefit from increased intake of some (not all) nutrients up to levels very considerably above those of ordinarily accepted adequacy. Ascorbic acid, vitamin A, and calcium are perhaps the best established cases of this kind. Conversely, it may be true of some other nutrient factors that surplus intakes should be held within bounds if undesirable consequences are to be avoided. The outstanding and undisputed example of the latter is the energy value or calories of the diet, of which any considerable surplus intake tends to induce overweight.

Recommendations of food calories should, therefore, seek to guard against too high, as well as against too low, an allowance. According to the National Research Council: "The proper calorie allowance is that which over an extended period will maintain the body weight (or rate of growth) at the level most conducive to well-being. Due account should be taken of the concept of 'ideal weight' as developed through the study of life-insurance experience. Height, age, sex, and environmental and genetic factors must also be taken into consideration. Obviously, single values cannot be equally accurate for different individuals whose needs are influenced by so many circumstances. Hence it is suggested that the recommended calorie allowances be regarded as subject to modifications of plus or minus 15 to 20 percent according to conditions."

Are the Recommended Allowances of 2400 Calories a day for sedentary men, 2000 for sedentary women, 2400 for moderately active women, and 3000 Calories for the average man who is physically

TABLE 12

RECOMMENDED DAILY DIETARY ALLOWANCES [a]
REVISED 1948

Food and Nutrition Board, National Research Council

	Calories [b]	Protein, gm.	Calcium, gm.	Iron, mg.	Vitamin A,[c] I.U.	Thiamine,[d] mg.	Riboflavin,[d] mg.	Niacin (Nicotinic acid),[d] mg.	Ascorbic acid, mg.	Vitamin D, I.U.
Man (154lb., 70 kg.)										
Sedentary	2400	70	1.0	12 [e]	5000	1.2	1.8	12	75	[f]
Physically active	3000	70	1.0	12 [e]	5000	1.5	1.8	15	75	[f]
With heavy work	4500	70	1.0	12 [e]	5000	1.8	1.8	18	75	[f]
Woman (123 lb., 56 kg.)										
Sedentary	2000	60	1.0	12	5000	1.0	1.5	10	70	[f]
Moderately active	2400	60	1.0	12	5000	1.2	1.5	12	70	[f]
Very active	3000	60	1.0	12	5000	1.5	1.5	15	70	[f]
Pregnancy (latter half)	2400 [g]	85	1.5	15	6000	1.5	2.5	15	100	400
Lactation	3000	100	2.0	15	8000	1.5	3.0	15	150	400
Children up to 12 yrs.[h]										
Under 1 yr.[i]	110/2.2 lb. (1 kg.)	3.5/2.2 lb. (1 kg.)	1.0	6	1500	0.4	0.6	4	30	400
1–3 yrs. (27 lb., 12 kg.)	1200	40	1.0	7	2000	0.6	0.9	6	35	400
4–6 yrs. (42 lb., 19 kg.)	1600	50	1.0	8	2500	0.8	1.2	8	50	400
7–9 yrs. (58 lb., 26 kg.)	2000	60	1.0	10	3500	1.0	1.5	10	60	400
10–12 yrs. (78 lb., 35 kg.)	2500	70	1.2	12	4500	1.2	1.8	12	75	400
Children over 12 yrs.[h]										
Girls, 13–15 yrs. (108 lb., 49 kg.)	2600	80	1.3	15	5000	1.3	2.0	13	80	400
16–20 yrs. (122 lb., 55 kg.)	2400	75	1.0	15	5000	1.2	1.8	12	80	400
Boys, 13–15 yrs. (108 lb., 49 kg.)	3200	85	1.4	15	5000	1.5	2.0	15	90	400
16–20 yrs. (141 lb., 64 kg.)	3800	100	1.4	15	6000	1.7	2.5	17	100	400

[a] Objectives toward which to aim in planning practical dietaries: The recommended allowances can be attained with a good variety of common foods which will also provide other minerals and vitamins for which requirements are less well known.

[b] Calorie allowances must be adjusted up or down to meet specific needs. The calorie values in the table are therefore not applicable to all individuals but rather represent group averages. The proper calorie allowance is that which over an extended period will maintain body weight or rate of growth at the level most conducive to well-being.

[c] The allowance depends on the relative amounts of vitamin A and carotene. The allowances of the table are based on the premise that approximately two-thirds of the vitamin A value of the average diet in this country is contributed by carotene and that carotene has half or less than half the value of vitamin A.

[d] For adults (except pregnant and lactating women) receiving diets supplying 2000 calories or less, such as reducing diets, the allowances of thiamine and niacin may be 1 mg. and 10 mg. respectively. The fact that figures are given for different calorie levels for thiamine and niacin does not imply that we can estimate the requirement of these factors within 500 calories, but they are added merely for simplicity of calculation. In the present revision, riboflavin allowances are based on body weight rather than caloric levels. Other members of the B complex also are required, though no values can be given. Foods supplying adequate thiamine, riboflavin, and niacin will tend to supply sufficient of the remaining B vitamins.

[e] There is evidence that the male adult needs relatively little iron. The need will usually be provided for if the diet is satisfactory in other respects.

[f] The need for supplemental vitamin D by vigorous adults leading a normal life seems to be minimum. For persons working at night and for nuns and others whose habits shield them from the sunlight, as well as for elderly persons, the ingestion of small amounts of vitamin D is desirable.

[g] During the latter part of pregnancy the calorie allowance should increase to approximately 20 percent above the preceding level. The value of 2400 calories represents the allowance for pregnant, sedentary women.

[h] Allowances for children are based on the needs for the middle year in each group (as 2, 5, 8, etc.) and are for moderate activity and for average weight at the middle year of the age group.

[i] Needs for infants increase from month to month with size and activity. The amounts given are for approximately 6 to 8 months. The dietary requirements for some of the nutrients such as protein and calcium are less if derived largely from human milk.

active but without heavy work, good group-average estimates of the food-energy levels most conducive to optimal nutritional status? This is what these allowances are intended and believed, by the National Research Council's Food and Nutrition Board (and by the present writer), to represent. But it has also been suggested that these allowances may be too liberal, and thus may be partly responsible for a present tendency to overweight in at least the men of sedentary occupations in the United States.

Thus Ancel Keys writes in *Nutrition Abstracts and Reviews* (Volume 19, No. 1), that the allowed amounts of food, if eaten, would result in obesity; but this will be true only on the assumption of either a suboptimal level of exercise, or a body weight less than 154 pounds (actual weight). If, as Keys appears to fear, we have a large proportion of men who eat beyond their calorie requirement, would they be better advised to eat less or to use their muscles more? "Or some of both?" If the food is chosen with sufficiently high regard for mineral and vitamin values, a simple cutting down of total food may suffice. But if he wishes to follow only about a present average choice of food then perhaps he would better work his muscles sufficiently to burn up as much food as he likes to eat in order that he may thus get the full values of an up-to-date diet without much modification of his accustomed dietary pattern. If he does his extra work in vegetable gardening and fruit growing he will almost automatically be improving his choice of food at the same time.

The situation and the problem, thus outlined in terms of American men, apply also to American women with the modification injected by the cult of stylish slenderness which for some decades has been incomparably more influential among girls and women than among boys and men. But this artificial disparity between the sexes will probably diminish as it comes to be more clearly and generally recognized.

In general, the individual who wishes to give himself the benefit of the newer knowledge of nutrition without conspicuous departure from accustomed American food patterns may be advised to make

up his mind how far he wishes to go in using the guidance of today's knowledge in his choice of food, taking account of the facts and trends summarized in Table 11 and its accompanying discussion in Chapter X. Then see whether the amount he likes to eat of a dietary modernized to the extent just suggested will maintain his body weight within the "ideal" of the life-insurance companies' experience—the range of weight for sex, height, and build as of age 25, as explained on pages 74 and 95 to 98 of the fifth edition of *Rose's Laboratory Handbook for Dietetics.* If the body weight then tends to go too high (1) exercise may be increased, or (2) choice of food may be revised so as to lower the calories but not the mineral elements or vitamin values, or (3) one may both increase the exercise and improve the choice of food.

The late Dr. Mary S. Rose wrote that to eat "in disproportion to one's need, whether on the side of deficiency or excess, is culpable." In her teaching she emphasized the research findings of Dr. Katherine Blunt and others, that underweight college women usually consider themselves "perfectly well" and then are surprised to find how much better they feel and how much more efficiently they work when they have fed themselves up to the standard weight for height and age. The cult of excessive slenderizing has had a very persistent vogue among American women, even while many other American women and perhaps most American men were tending to allow their body weights to exceed the "ideal zone" of life-insurance experience. "A lean horse for a long race" is an adage still valid so far as it goes, but all who take thought to keep calories and body weight down should also be careful to keep the calcium contents and the vitamin values of their dietaries up.

TWO WAYS OF BALANCING DIETARIES AND FOOD SUPPLIES

Now that we have outgrown the idea of balancing diets or food supplies simply in terms of proteins, fats, and carbohydrates (or their calories), there are two ways of balancing which take account of the newer knowledge of mineral elements and vitamins. One way

is through actual calculations of individual nutrients or nutrient factors—not all forty or so of them, which we recognize as essentials of human nutrition; but of enough of them so that it may be assumed that a diet adequate with respect to all of these will provide enough of other nutrients to meet all normal needs. This plan is both illustrated and implemented by the National Research Council's Recommended Allowances, here reproduced in Table 12. The other outstanding plan is to call for a dietary or food supply of specified calorie value and containing stated amounts of specified foods or "food groups," as illustrated in Table 13 (pages 218–19), from the U.S. Department of Agriculture's Miscellaneous Publication No. 662 (1948). The plan summarized in Table 13 represents the "pattern" which prevails in the United States with amounts adjusted to provide excellent nutritive value at relatively low cost.

Improvement of our American food habits under nutritional guidance will usually mean somewhat less prominence of meats, fats, and sweets, and somewhat more of fruits, vegetables, and milk (with its products other than butter). This trend is in part already apparent. It can and should continue.

The newer knowledge of nutrition now includes the results of much research directly with human beings as well as with many hundreds of carefully controlled experimental animals often studied throughout entire natural lifetimes and successive generations. While these results "reveal much more than had been foreseen" they are the findings of many laboratories and of several years of continuous, objective, and statistically convincing scientific work. Thus research has carried the science of nutrition through the stage of opinion into the realm of established facts and principles. These we have here attempted to summarize without technicalities, yet with due respect to their far-reaching significance for the improvement of human life both in its biological and in its more-than-biological aspects. For although much remains to be done in working out the relationships between body and mind as influenced by nutrition there is no longer room to doubt the fact that nutritional status can affect the human spirit. Through nutritional guidance in

our use of everyday foods we can build higher health and efficiency even in those who are already healthy and efficient. And the extra years, which the newest knowledge clearly offers, are not simply added to old age but are to be pictured as inserted at the apex of the prime of the life which is lived in accordance with the principles of the present-day science of nutrition.

Table 13

A Widely Applicable Food Plan, from the U.S. Department of Agriculture's Miscellaneous Publication No. 662. Weekly Quantities of Food (as Purchased) for 19 Age, Sex, and Activity Groups

Family members	*Leafy, green, and yellow vegetables*	*Citrus fruit, tomatoes*	*Potatoes, sweet-potatoes*	*Other vegetables and fruit*	*Milk* [a]	*Meat, poultry, fish*	*Eggs*	*Dry beans and peas, nuts*	*Flour, cereals* [b]	*Fats and oils*	*Sugar, sirups, preserves*
Children through 12 years:	*Lb. Oz.*	*Lb. Oz.*	*Lb. Oz.*	*Lb. Oz.*	*Qt.*	*Lb. Oz.*	No.	*Lb. Oz.*	*Lb. Oz.*	*Lb. Oz.*	*Lb. Oz.*
9–12 months	1—8	1—12	0—8	1—0	6	0—4	5	0—1	0—10	0—1	0—1
1–3 years	1—8	1—4	1—8	0—8	5½	0—6	4	0—1	1—8	0—2	0—2
4–6 years	1—8	1—8	2—0	0—12	5½	0—8	3	0—4	2—4	0—6	0—4
7–9 years	1—12	1—8	3—0	0—12	5½	0—12	3	0—6	3—0	0—8	0—8
10–12 years	2—0	1—8	3—8	1—4	6	1—0	3	0—8	3—8	0—12	0—12
Girls:											
13–15 years	2—0	1—12	4—0	1—8	6½	1—0	4	0—8	3—12	0—12	0—12
16–20 years	2—0	1—12	3—8	1—8	4½	1—0	4	0—8	3—12	0—12	0—12
Boys:											
13–15 years	2—0	2—0	4—4	1—8	6½	1—4	4	0—12	4—12	1—2	0—14
16–20 years	2—4	2—0	5—8	1—8	6½	1—4	5	0—14	6—0	1—6	1—0
Women:											
Sedentary	2—0	1—8	3—0	1—4	5	1—0	4	0—4	3—0	0—8	0—8
Moderately active	2—0	1—8	3—8	1—8	4½	1—0	4	0—8	3—12	0—12	0—12
Very active	2—0	1—8	4—8	1—8	4½	1—0	4	0—12	4—12	1—0	0—14
Pregnant	2—12	2—0	3—0	1—8	7½	1—4	5	0—6	3—0	0—8	0—8
Nursing	3—0	3—12	4—4	1—8	10½	1—8	5	0—6	3—8	0—12	0—8
60 years or over	2—0	1—12	3—4	1—0	5	1—0	4	0—4	3—0	0—8	0—8

Men:											
Sedentary	2—0	1—8	3—8	1—8	4½	1—0	4	0—8	3—12	0—12	0—12
Physically active	2—0	1—8	4—8	1—8	4½	1—4	4	0—12	4—12	1—0	0—14
With heavy work	2—0	1—8	7—0	1—8	4½	1—4	5	1—0	7—12	1—14	1—4
60 years or over	2—0	1—12	4—0	1—4	5	1—0	4	0—6	3—12	0—10	0—10

[a] Or its equivalent in cheese, evaporated milk, or dry milk. When using the following foods, count the quantity given for each as about equal in calcium to 1 quart of milk:

Evaporated milk	17 ounces (by weight).
Cheese, Cheddar type ..	5 ounces.
Cheese, cottage	3 pounds.
Ice cream	Nearly 2 quarts or about 12 large dips.

[b] Count 1½ pounds of bread as 1 pound of flour. Use as much of this as possible in the form of whole-grain, enriched, or restored products.

Note: The original publication has somewhat fuller footnotes.

Appendices

APPENDIX A

The 1946 World Food Survey of the Food and Agriculture Organization of the United Nations

EARLY IN 1946 the Food and Agriculture Organization of the United Nations (FAO) brought together temporary committees on nutrition targets and on prewar food consumption who did what they could in a very limited time to estimate what the world's food supply had been and what it ought to be in order to provide adequate nutrition for full health. These estimates were published in July 1946 under the title, *World Food Survey.* In this publication the lack of complete and accurate data is frankly acknowledged. Thus on page 5 we read:

"It need scarcely be said that the figures for many countries are highly imperfect. Statistical services in most countries will have to be vastly improved before complete and accurate data are obtainable; it is one of FAO's functions to help bring about this improvement, which will take many years."

This *World Food Survey* covered 70 countries, estimated to contain about 90 percent of the world's population. (From the countries containing the remaining 10 percent it proved impossible to obtain usable data.)

It is estimated that about one half the world's population live in areas which have less than 2250 Calories per person a day (averaging about 2000; "low-Calorie areas"); that about one third live in areas having over 2750 Calories per person (averaging about 3000; "high-Calorie areas"); and that about one sixth live in areas having between 2250 and 2750 Calories a day. Thus the high-calorie areas average about half again as much food energy as the low-calorie areas.

From this survey it appears that the people of the high-level areas eating about 3000 Calories and those of the low-level areas eating about 2000 Calories each eat about 1000 Calories in cereal products, but the high-level populations usually had enough of other foods high in protein, mineral elements, and vitamins to give them reasonably balanced diets; while the people of the low-calorie areas usually did not, for in general they are also the low-income people. In this world view,

as in the studies made in the United Kingdom and the United States in the 1930s, people with sufficiently large purchasing power usually provided themselves diets sufficiently abundant and varied to include adequate amounts of all nutrients. "Poverty is the chief cause of malnutrition."

"*Nutritional Targets*. . . . The problem of dietary standards or allowances for international application is one with which both FAO and the World Health Organization will be concerned in the future. In the United States of America the recommended daily allowances of the National Research Council (NRC) have been widely accepted and are used by official agencies. . . . But in many of the countries with a medium calorie intake, and in all those with a low intake, consumption goals must be set considerably below the optimum if they are to be reached within a reasonable time. "The achievement of such intermediate goals would bring a vast improvement in world nutrition." Hence, FAO decided, "that in drawing up targets weight must be given to the present position as regards the production and supplies of the various foods, and that the targets should call for modification in existing dietary patterns rather than revolutionary changes." And in accordance with that general principle, the targets set up in this 1946 publication were determined mainly as follows:

(1) A per person calorie intake of 2550–2650 was taken as the minimum level to which intake should be raised in the low-calorie countries, while in each country whose prewar level was higher it was left as the postwar target for total calorie consumption though often with the recommendation of a different quantitative distribution of the different types of food (food groups).

(2) "If calories from cereals fall between 1200 and 1800, no change should generally be recommended. If they fall below 1200, and if total calorie intake is below 2600, some increase in cereal intake may be recommended unless the total calories from cereals, starchy roots and tubers and starchy fruits, sugar, fats, and pulses exceed 2000–2100. . . ."

(3) Starchy roots and tubers (with such starchy fruits as bananas and plantains) are regarded with favor at levels of 100 to 200 Calories (of such foods) a day depending upon the amounts of other starchy foods eaten.

(4) "In general, no increase in the intake of sugars should be recommended. If calories from sugar exceed 10 to 15 percent of total, some reduction may be considered, with due regard to the dietary pattern as a whole."

(5) Commodity fats "as a separate food group" (sometimes called

visible fats) are recommended to furnish at least 100 and preferably 150–200 Calories per person per day. "Intake of fat through the medium of other food groups must be taken into consideration."

(6) Pulses (legumes) are given a very elastic place in the targets of different countries according to their meat supplies and dietary patterns.

(7) Fruits and vegetables, exclusive of the starchy kinds, and giving preference to those which are good sources of vitamin C, should be included in the dietary to at least the extent of 100 Calories per person daily.

(8) Meat (including poultry), fish, and eggs are recommended to furnish, "not less than 100 Calories per person daily, and preferably 150–200."

(9) Of milk with its products other than butter, this FAO (1946) publication states: "An intake of 300–400 Calories per caput daily represents a desirable minimum level of consumption. . . ."

The foregoing has been given largely in the exact words of the FAO publication, *World Food Survey* (1946), in order to convey precisely the Organization's view of how and why it used the criteria of nutritional science elastically rather than rigidly in setting the targets which it recommends to the respective countries or regions. The advantages of a universal nutritional "yardstick" were deemed to be outweighed by the advantages of individualized targets, each representing a step in the direction indicated by nutritional considerations but going only so far as seemed practicable of attainment with reasonable promptness taking full account of national food customs and economic conditions.

The targets raise to 2600 Calories per person all national averages found below that figure, but national figures higher than that level are left so. Thus even in calories the targets do not all represent the same standard; and much wider differences occur in some of the targets for individual foods. In the case of milk, the targets recommended to several countries are less than half as high as those recommended to several other countries.

This report adopts the term *original calories* for the calories yielded by crops. "About seven of these original calories are required to produce one calorie from animal products." This needs discrimination as to *which* animal products. The seven calories of grain which would produce one calorie of egg or of *moderately* grain-fed beef could produce at least twice as much, two calories or more, of milk, while the same seven calories of grain if turned into *heavily* grain-fed beef could produce only about one half a calorie of such beef.

FAO uses the 7:1 relationship as follows: "The prewar North Ameri-

can diet contained about 2200 Calories per caput daily from foods of plant origin and about 870 Calories from livestock products. If the latter figure is multiplied by seven, the total value of the diet in original calories becomes . . . 8290. At the other end of the scale, the diet of certain islands in Southeast Asia contained about 1940 Calories from plant products and only 100 from livestock products which gives . . . 2640 as the total value in original calories." Thus the cost of the North American diet in original calories or food production resources was three times that of the diet in Southeast Asia.

APPENDIX B

Records of Actual Food Consumption

At many points this book, in tracing the advances in knowledge which make possible a nutritional improvement of life has put the findings in terms not only of nutrients but also of the types of food commodities through which the nutrients are actually obtained in practice. And the Bibliography includes an entry under Bureau of Human Nutrition on helping families to plan food budgets.

In addition, some readers may be interested in the question how an attempt to use food in accordance with the guidance of present-day knowledge of nutrition is likely to work out in the case of an individual who—like most of us—has partial freedom to choose what foods to eat and how much of each, but also must for practical reasons conform to the general patterns of twentieth-century food habits, modifying emphases within these patterns without attempting to ignore them to any inconsiderate or impracticable degree.

One individual, so situated, and interested in the practical application of nutritional knowledge, recorded each serving of certain foods eaten during one year. This record showed 1577 servings of fruit and fruit products; 275 servings of tomato or tomato juice; 1407 servings of other vegetables; and during the same year the same person consumed 300 servings of meat, poultry, fish and shellfish, and 116 servings of eggs.

In another case a fuller record was continued for four years (1461 consecutive days). The total numbers, thus eaten, of servings of certain types of food were: of fruit, 7617 servings; of vegetables, 7311; of milk and its products other than butter, 6625; of breadstuffs and other grain products and bakery goods, 5697; of fats, 2299; of meats, fish, and poultry, 1068; of nuts (including peanut butter), 342; of eggs, 288; (total servings of meats, fish, poultry, eggs, and nuts, 1698); of sugars and sweets (not counting additions of sugar to other foods in cooking and preserving), 262 servings. This averages: of fruits and vegetables each about 5 servings a day; of milk in some form, including cheese, cream, and ice cream but not butter, 4 to 5 servings a day; breadstuffs and cereals, 4 servings a day; butter and other fats, 11 servings a week; meats and "meat substitutes" (including eggs and nuts but leaving beans and peas with the other vegetables), 8 servings a week; half-servings of

sweets, not including ice cream or preserved fruits, 2 or 3 a week. In order fully to conform to the tradition of meat as a main dish once a day, we here give the count of consumption of meat and only its universally recognized substitutes, eggs and nuts, though as a matter of fact in the meals of the person here studied baked beans were substituted for meat probably as often as were eggs and more often than were nuts. Cheese fondue was also a fairly frequent main dish. Thus the traditional pattern can be fully preserved, while the food habit is materially modified in the direction suggested by recent developments of our knowledge of nutrition.

The following is the record of a random (presumably fairly typical) month in the second half year of this four-year study: [1]

July 1—I: Orange juice; coffee; hot milk; toast and butter; raw apple. II: Orange juice; string beans; creamed potatoes; milk; toast and butter; ice cream with strawberries; raw apple. III: Orange juice; toast and butter; milk; peaches and cream.

July 2—I: Orange juice; coffee; hot milk; toast and butter; cantaloupe. II: Milk; toast and butter; grapefruit juice. III: Lettuce and tomato salad; wafers; buttermilk.

July 3—I: Cantaloupe; coffee with thin cream; toast, butter and marmalade; milk. II: Tomato madrilène; corn muffin, roll, and butter; lamb chop mixed grill; parsley potato; cauliflower; iced tea; raspberry sherbet. III: Milk toast; grapefruit juice.

July 4—I: Coffee; shredded wheat; cream and milk; grapefruit juice. II: Vegetable soup; string beans; milk; toast and butter; grapefruit juice. III: Mixed vegetables; milk toast; peaches.

July 5—I: Grapefruit juice; coffee; evaporated milk; shredded wheat; raw apple. II: Fruit juice; milk biscuit and butter; spaghetti in cream au gratin; string beans; egg plant; apple pie with cheese; milk. III: Shredded wheat and milk; orange.

July 6—I: Cantaloupe; coffee; evaporated milk. II: Manhattan clam chowder; egg yolk, tomato, cabbage and lettuce salad; carrots, Vichy; creamed kohlrabi; rice and whole-wheat muffins and butter; strawberry ice cream; milk. III: Cabbage and tomato salad; buttermilk.

July 7—I: Coffee; milk; orange. II: Cold consommé with lemon; corn bread and butter; creamed finnan haddie, Delmonico; fresh Lima beans; escalloped tomatoes; lemon and raspberry sherbet; milk. III: Grapefruit juice; buttered boiled onions; milk; toast; orange juice.

[1] Records for the first six months are appended to the first edition, and those for the first and sixth months are in the second edition, of the writer's *Food and Health* (Macmillan).

July 8—I: Coffee; hot milk; toast and butter; orange juice (l.).[2] II: Orange juice; baked potato and butter; string beans; hot milk; leaf lettuce with a little French dressing; banana. III: Milk toast; grapefruit juice.

July 9—I: Coffee; hot milk; toast and butter; grapefruit juice. II: Tomato juice; creamed kohlrabi; bran muffin and butter; fruit salad (l.); strawberry ice cream; milk. III: Tomato juice; toast and butter; hot milk; baked potato; summer squash; cantaloupe. IIIa: Orange juice.

July 10—I: Coffee; hot milk; toast and butter; banana and orange. II: Tomato purée; Southern biscuit and butter; baked fresh mackerel à l'Italienne; parsley potatoes; string beans; orange sherbet; milk. IIa: Orange juice. III: Orange juice; toast and butter; hot milk; escalloped tomato, onion and green pepper; baked banana; grapefruit and leaf lettuce salad.

July 11—I: Coffee; milk; toast and butter; grapefruit juice. II: Vegetable stew; milk; toast and butter; orange juice (l.). III: Tomato juice; fried eggs and bacon; mashed potatoes; peas; buttered cabbage; bread and butter; milk; cherry pie.

July 12—I: Fresh raspberries with cream; coffee; milk; toast and butter. II: Lemon milk sherbet; celery, olive; creamed chicken with mushrooms; butter beans; escalloped potatoes; "milkwheat" roll; "milkcorn" muffin, and butter; lettuce salad with cottage cheese; ice cream with cake; milk; coffee with cream. III: Bananas, crackers, grapefruit juice, fig newtons.

July 13—I: Honeydew melon; coffee with cream; rice crispies with cream; egg yolks and bacon; toast and butter. II: Barley and vegetable soup; sweet pickles; baked salmon with lemon and parsley; boiled potato with butter; string beans; chocolate pie. III: Scrambled eggs; hashed browned potatoes; bran muffin, cornmeal fritter, butter; pickled watermelon rind; salmon salad; canned pear; milk.

July 14—I: Banana and orange; coffee with cream; cornflakes and milk; bran muffin and butter; egg yolk and bacon. II: Rice consommé; bread and butter; steak; boiled potato; sweet pickle; beet greens with small beets and tomato ketchup; graham pudding; weak tea with much lemon. III: Creamed dried beef; potato boiled in jacket; baked beans; sweet pickle; canned pineapple; milk; corn bread and butter.

July 15—I: Raw pear, cornflakes; milk; coffee; griddle cakes with butter and maple sirup. II: Clear vegetable soup; radishes; turkey with cranberry sauce; mashed potato; peas; spiced pickled pineapple; bread and butter; lemon pie; tea with lemon. III: Scrambled eggs; potato cake;

[2] l. indicates an extra large serving.

bread and butter; tomato and leaf lettuce salad; canned peaches; tea with lemon.

July 16—I: Bananas, cornflakes and milk; coffee with thin cream; bread and butter; egg yolk and bacon. II: Cream cheese and date sandwich; potato salad; blueberry pie; coffee with cream. III: Tomato juice; Julienne soup; Vermont chicken pie; hashed browned potatoes; string beans au gratin; sweet pickle; roll and butter; milk; honeydew melon.

July 17—I: Honeydew melon; coffee; milk; toast, butter and marmalade. II: Clear tomato soup; roast lamb; mashed potato; creamed string beans; beets; bread and butter; fruit salad; blueberry pie; milk. III: Fruit cup; tomato bouillon; roll and butter; lamb chop; parsley potato; summer squash; peas; rhubarb conserve; coleslaw salad; milk; honeydew melon with lemon.

July 18—I: Honeydew melon; coffee with cream; toast, butter and marmalade; milk. II: Grapefruit juice; purée Mongole; roast chicken; mashed potato; Golden Bantam corn; rolls and butter; celery and nut salad; blueberry pie; milk. III: Consommé; baked ham, potato, peas; lettuce salad; bread and butter; blueberry pie; milk.

July 19—I: Orange juice; cornflakes with thin cream; coffee with thin cream; toast, butter and marmalade; egg yolks and bacon. II: Orange juice; banana; milk; toasted raisin bread and butter; tomato and onion salad with very little French dressing. III: Grapefruit juice; golden bantam corn; milk; toast and butter; fruit salad.

July 20—I: Orange juice; coffee; hot milk; toast and butter. II: Blackberry juice; fruit salad (l.); roll and butter; strawberry ice cream; milk. III: Orange juice; creamed potato; toast and butter; milk; lettuce, tomato, and cream cheese salad (no dressing); peaches and cream.

July 21—I: Grapefruit juice; coffee; milk; raisin toast and butter. II: Orange juice; creamed potato; milk; succotash; young beets with beet greens; toast; peaches and cream. III: Orange juice; fig newtons; milk; lettuce, tomato, green pepper and cottage cheese salad (no dressing); peaches and cream.

July 22—I: Grapefruit juice (l.); coffee; hot milk; toast and butter. II: Orange juice; succotash (fresh Lima beans and Golden Bantam corn); summer squash; tomato and leaf lettuce salad; toast; peaches with ice cream; milk. III: Grapefruit juice; corn bread and butter; peaches; milk.

July 23—I: Coffee; milk; toast and butter; banana; orange juice. II: Apricot juice; butterfish with lemon; string beans; stewed tomatoes; corn muffin, butter; strawberry ice cream; milk. III: Orange juice;

golden bantam corn; leaf lettuce, tomato and cream cheese salad (no dressing); toast; peaches; milk.

July 24—I: Coffee; milk; toast and butter; grapefruit juice. II: Orange juice; egg-yolk salad; corn bread and butter; peaches and cream; milk. III: Orange juice; vegetable stew, mixed pickles; toast and butter; peaches and cream; milk.

July 25—I: Orange juice; coffee; hot milk; toast and butter. II: Vegetable soup; milk; toast and butter; fruit salad; gingerbread; peaches and cream. III: Consommé; vegetable stew; toast and butter; peaches and cream; milk. IIIa: Orange juice.

July 26—I: Cantaloupe; coffee; hot milk; toast and butter. II: Tomato juice; grilled sea trout with lemon; sweet potato; creamed celery; corn bread and butter; doughnut and apple sauce; milk. III: Grapefruit juice; liver, bacon, cabbage, apple; vegetable salad (no dressing); toast; peaches and cream; milk.

July 27—I: Coffee; hot milk; toast and butter; orange juice. II: Manhattan clam chowder; grilled sea bass with lemon; pan roast potato; escalloped tomato; roll and butter; fresh peach cobbler; milk. III: Grapefruit juice; raisin bread and butter; apple pie with old English dairy cheese; milk.

July 28—I: Coffee; hot milk; raisin bread toast and butter; peaches and cream. II: Tomato juice; scrambled eggs; creamed spinach; buttered beets; Southern biscuit and butter; strawberry ice cream; milk. III: Orange juice; peas; toast and butter; apple pie and cheese; milk.

July 29—I: Orange juice; coffee; hot milk; raisin bread toast and butter. II: Orange juice; succotash; baked potato with butter; milk; vegetable salad (no dressing); ice cream with toast. (Toast rather than cake with ice cream; for the pleasing contrast of texture and for the lower calorie, and higher vitamin[?], intake.) III: Orange juice; raisin bread toast and butter; peaches and cream; milk.

July 30—I: Coffee; hot milk; toast and butter; orange juice. II: Plum juice; omelette with chicken liver; parsley potato; kale; corn muffin and butter; strawberry ice cream; milk. III: Orange juice; buttered boiled onions; milk; toast; peaches and cream.

July 31—I: Coffee; hot milk; toast and butter; orange juice. II: Vegetable soup (l.); bread; milk; orange, small, with skin. III: Toast (wholewheat, as usual); peaches and cream (l.).

APPENDIX C

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